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Energy Audit and Conservative Measures of a Typical 3BHK Flat

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Abstract: Energy today has become a key factor in human sustenance and growth. The increased demand of energy and shortage in power generation is day by day, the gap between demand and supply of electric energy is widening. It is very difficult and expensive scheme, bridging this crack from the resource side. To handle this crisis, identifying opportunities for reducing the amount of energy used and ensuring that the available energy is used efficiently are essential. Systematic method in checking energy usage and wastage is the Energy Auditing. Energy audits provides the vital information base for overall energy conservation program which has several goals, essentially energy utilization analysis evaluation of energy conservation measures to reduce energy consumption, management costs, and environmental effect. This paper presents such energy saving methods in a methodological approach, practiced during a detailed energy audit of a 3BHK flat. The case-studied flat is a three-BHK flat, Gautaminagar colony, Aswapuram, Telangana state India. It aims at identifying the ways with or without financial investment, to attain estimated saving's in energy and cost. Considerable energy saving is possible through proper choice of equipment, and their effective use and involvement of conservation measures. Detailed calculations are made with respect to savings and a conclusion of payback period is arrived

Keywords: Energy audit, efficiency, LED, demand, A/C, BLDC fan

I. INTRODUCTION

Energy is one of the key factors contributing economic development of any country. Electricity is the main energy source used in most building's and industries. Indeed, electricity is required for the operation of numerous appliances in all residential building. Residential or domestic load consists of lights, fans, and appliances like heaters, electric irons, refrigerators, coolers, electric water heaters, washing machines, amongst others Availability of power has a crucial role. India's power capacity has risen from 34000 MW to 82580 MW at the rate of 5.87% per annum over the last 25 years. India is the world's third largest producer and third largest consumer of electricity. The national electric grid in India has an installed capacity of 370.106 GW as of 31 March 2020[1].Renewable power plants, which also include large hydroelectric plants, constitute 35.86% of India's total installed capacity In recent times, sustainable building, green building, eco design building, bioclimatic design building and many more have become popular in the building sector. This terminology and their significance differ somewhat, but the purpose is the similar with intents advancing more efficient utilization of natural resources, especially energy and water, and using renewable energy in the maintenance of the buildings. In general energy conservation in buildings can be achieved by retrofit actions on space side heating, cooling, lighting, window glazing's, occupancy sensors, electrical equipment [2], lifts, escalators, cold deck temperature set point and reduced ventilation air, etc., Energy conservation means an effort made to reduce the consumption of energy by using less of an energy service without making any compromising on quantity or quality. A successful energy management program begins with energy conservation; it will lead to suitable. rating of equipment's, using high efficiency equipment and change of habits which causes enormous wastages of energy. Also limited energy resources, scarcity of capital and high interest costs for the addition of new generation capacity is leading to the increased cost of electrical energy in India. The only executable way to handle this crisis, apart from capacity addition, is the efficient use of available energy, which is possible only by monitoring and controlling the use of electrical energy continuously. Hence energy management program is a systematic and scientific process to identify the potential for improvements in energy efficiency, to recommend the ways with or without financial investment, to achieve estimated saving energy and energy cost. Due to peak demand, strain on power generation and utilization equipment increases which result into Increases in energy cost. Considerable energy saving is possible through proper choice of equipment's, and their effective use & involvement of conservation measures. The demand for electricity continues to rise as population grows. Electrical energy demand refers to the maximum amount of electrical energy that is being consumed at a

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giving time. It is necessary, for system planning and operation, to know the total electrical energy requirements and the duration of various loads in residential apartments. This is necessary to give residential consumers and building owners a proper sense of how much energy different appliances and activities consumed, because most people consistently overestimate the impact of less energy consuming appliances and less effective conservation activities and under estimate the impact of energy of more energy consuming appliances and more effective conservation activities.

II. ENERGY AUDIT

Energy audit involve gathering system information, measuring energy use, developing conservation strategies choosing the most cost-effective plan, implementing changes, and verifying results Reducing the resource consumption of an existing flat is often possible and convenient. However, initiating the process of implementing the changes might be complex if the concerned person has little skill or no awareness of the energy status of their houses. Hence somewhat knowledge and steps are required to conserve the energy worldwide using systematic approach. Furthermore, a wide-ranging method in checking energy usage and wastage is energy-efficient technologies are to be ensured for proper energy conservation [3].

A. Necessity for energy audit.

Energy Audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where it occurs and where the scope for improvement exists. The Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programs which are vital for production and utility activities. Such an audit programme will help to keep focus on variations which occur in the the "Energy Audit". Energy audits do not provide the complete solution to the complication. This identifies where the potential for development lies, and therefore, where energy management efforts must be directed. An energy survey and audit of households is the process by which a house is inspected and examined to determine how energy is used in it, with the aim of identifying opportunities for reducing the amount needed to operate the house still maintaining comfort level. The process is periodic in nature, and it assesses changes in usage of household appliances. The condition of existing equipment, and the applicability of new energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc. In general, Energy Audit is the translation of conservation ideas into realities, by lending technically feasible solutions with economic and other organizational considerations within a specified time frame. The primary objective of Energy Audit is to determine ways to lessen energy consumption per unit of product output or to lower operating cost.

B. Sequential procedure of energy audit include:

i. Data collection: collecting some preliminary information on the energy consumption of the facilities and some technical details
ii. Field work: The aim of gathering all the information needed for the study depending on the defined scope
iii. Analysis of energy consumption and performance of energy accounting: all the operations of the organization must be analysed, as well as the equipment consuming higher energy.
iv. Analysis and development of energy saving measures: Energy and cost savings of these measures will be assessed, together with investment needed and payback
v. Energy audit report**:** Following the energy audit, an energy audit report must be issued, which should include at least the following information:
    a) Technical Scope
    b) Methodology
    c) Suggested energy saving measures
    d) conclusions

a) Technical Scope: This point includes facilities, services and included areas and level of depth in the analysis and detail required

b) METHODOLOGY: This point includes the analysis of the state of art of the facilities (energy inputs, technologies and services), measurement results and energy balance, it comprises theoretical analysis of the body of methods and principles associated with branch of knowledge. Following steps to be followed for energy audit:

- Primary data collection, process flow diagram, energy utility diagram and collection of any other relevant data
- Conduct survey and monitoring
- Conduct detailed trials / experiments for the selected energy guzzlers
- Analysis of energy use

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- Identification and development of energy conservation opportunities
- Cost benefit analysis
- Implementation, commissioning and follow up

Primary Data Collection: This is to identify how electricity supply was received by the flat, the appliances used their wattage specifications and the number of hours they operated.
Energy Audit: The energy outlets in all the rooms were identified. The energy ratings of all the appliances were noted and the mean operating time was taken. The domestic load consists of lights, fans, and appliances like radios, heaters, electric irons, refrigerators, coolers, electric water heaters, washing machines and others were calculated and tabulated. The total energy consumption of the block was found
Energy Conservation: The energy necessity from the energy audit and was to be reduced by suitable methods. Various fixtures like LED lights were substituted instead of conventional fixtures. The total energy reduction was calculated. The effectiveness of each of the improvements was studied and tabulated.

II. ENERGY EFFICIENT TECHNIQUES:

A. Lighting:

Type of lamp	LED	CFL	INCANDECENT	FLUROSCENT
Expected life (hours)	>50000	10000	1000	5000
Luminous efficacy (l/w)	100 to 120	60 to 70	8 to 15	50 to 60
Cost of lamp per watt (INR)	15	15	2	1
CRI	90-100	60-70	90-100	100-120

Using LED lights have many benefits, from being durable to being energy-efficient, LED lights have satisfied each and every requirement. Previously, most of us have used fluorescent lights, but after knowing that it can be really harmful, many of us have switched to LEDs, but still, there are some people who have not switched to LEDs and are using fluorescent tube lights.

Benefits of LED Lightbulbs:

i. Long-Lasting

ii. LED bulbs last up to 10 times longer than compact fluorescents, and 40 times longer than typical incandescent bulbs.

iii. Durable

The cost of new LED bulbs has gone down considerably in the last few years and is continuing to go down. To see a cost comparison between the different types of energy saving light bulbs.
The above Energy savings over 25000hours assuming 25 bulbs per house hold

Since LEDs do not have a filament, they are not damaged under circumstances when a regular incandescent bulb would be broken. Because they are solid, LED bulbs hold up well to jarring and bumping.

iv. Cool

These bulbs do not cause heat build-up; LEDs produce 3.4 BTU's/hour, compared to 85 for incandescent bulbs. Common incandescent bulbs get hot and contribute to heat build-up in a room. LEDs prevent this heat build-up, thereby helping to reduce air conditioning costs in the home.

v. Mercury-free

No mercury is used in the manufacturing of LEDs.

vi. More-Efficient

LED light bulbs use only 2-17 watts of electricity (1/3rd to 1/30th of Incandescent or CFL). LED bulbs used in fixtures inside the home save electricity, remain cool, and save money on replacement costs since LED bulbs last so long. Small LED flashlight bulbs will extend battery life 10 to 15 times longer than incandescent bulbs.

vii. Light for Remote Areas and Portable Generators

A comparison between traditional Fluorescent, Incandescent, CFF and the LED is shown in Table 1.

B. CEILING FANS:

The ceiling fan industry is also in the cusp of such a transition. BLDC is the new revolution in the fan industry. And it is only a matter of time before all old inefficient induction motor fans will be replaced by smart super-efficient BLDC fans. BLDC technology has been in the market for many years now and it is widely used in industries where high torque motors are required. What was missing so far is its application in

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ceiling fans. But, this is rapidly changing as of today. A BLDC fan takes in AC voltage and internally converts it into DC using SMPS.

The main difference between BLDC and ordinary DC fans is the commutation method. A commutation is basically the technique of changing the direction of current in the motor for the rotational movement. In a BLDC motor, as there are no brushes so the commutation is done by the driving algorithm in the electronics. The main advantage is that over a period of time, due to mechanical contact in a brushed motor the commutators can undergo wear and tear, this thing is eliminated in BLDC Motor making the motor more rugged for long-term use. A brief comparison is shown inhe electronics contains a driving algorithm which drives the BLDC motor; as shown in fig 1. In a BLDC motor the position of magnets in the fan is sensed by electronics that either uses a Hall effect sensor or back EMF. Modern BLDC motors use Back EMF for commutation due to proven disadvantages of hall effect sensor over period of time.

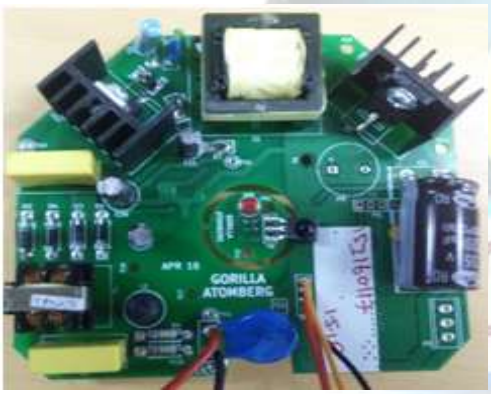
To increase the torque of the motor, modern motors excite the other 2 phases too to create repulsion hence increasing the torque of the motor.

Permanent magnets used in rotor are responsible for mass reduction in power consumption compared to windings used in the stator in an ordinary induction fan. One added advantage in a BLDC fans due to use of an electronic circuit is that you can add several additional features to increase convenience, few examples of the same are sleep mode, timer mode also it is compatible with Home automation systems. Most of the BLDC Ceiling fans are operated by remote unlike traditional regulator reducing the purchase cost of regulator.

Compared to regular induction fan, a BLDC fan can save up to Rs 1000-1500/ Year/fan. And because there is no heating of the motor, the life of a BLDC fan is also expected to be much higher than ordinary fans.

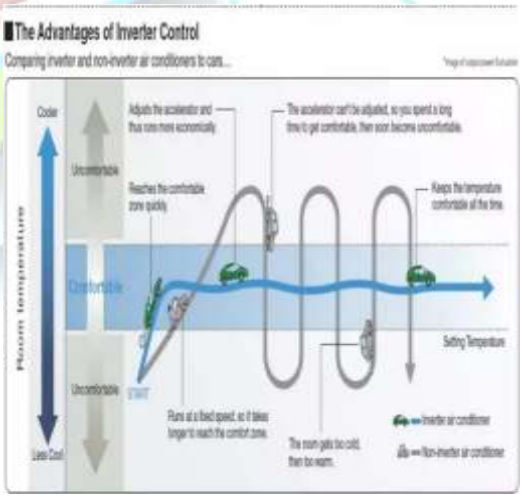
Fig 1. Electronics in a BLDC Fan motor

IV) STAR RATING FOR ENERGY EFFICIENCY:



A star rating system depicts the energy efficiency of an electrical appliance. The higher the number of stars, the more efficient it is. The star rating system was devised by the Bureau of Energy Efficiency (BEE) India, with a range of 1 to 5 stars. This system ensured that the energy efficiency of appliances was easily understood by the common man. With improving technology, the efficiencies of air conditioners have improved with time. The best air conditioners available in the market today consume 30% to 50% less electricity than those that were available in mid 1970s. In fact the efficient models available today are about 20-40% efficient than the models that were available 10 years ago(source). And because there is a lot of push for efficiency because of energy shortage/climate change, the efficiencies will improve much more in the coming years. As energy shortage will force increase in prices of electricity, it will make much more sense to buy efficient air conditioner, as savings in the electricity bills will recover the additional cost of buying efficient air conditioner.

In case if the current electricity bills are extremely high (because of high usage), then buying a BEE 5 star rated air conditioner will be the best solution [4]. Energy efficiency is defined as the "energy service per unit of energy consumption". It is a simple and fair way of comparing the



energy consumption of products that perform a similar task. 5 - Star A/Cs are the most energy efficient systems that help save significant money on electricity bills throughout the lifecycle of the A/C. The life cycle cost of an air-conditioner is a combination of initial cost, running

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cost and maintenance cost. Most make a decision on buying a particular AC based only on the initial cost, without knowing that it contributes to just 11% of the total expense of owning an A/C. The running cost of an AC contributes to over 60%. At present with the incorporation of power electronics into electrical appliances, A/C can be classified as regulator and inverter type.

Figure 2. Normal and Inverter Air conditioner

- In a regular air conditioner**:**

The compressor is either off or on. When it is on, it works at full capacity and consumes full electricity it is designed to consume. When the thermostat reaches the temperature level set in the AC, the compressor stops and the fan (in AC) continues to operate. When the thermostat senses that the temperature has increased, the compressor starts again

- Inverter air conditioner:

The inverter technology works like an accelerator in a car. When compressor needs more power, it gives it more power. When it needs less power, it gives less power. With this technology, the compressor is always on, but draws less power or more power depending on the temperature of the incoming air and the level set in the thermostat. The speed and power of the compressor is adjusted appropriately. This technology was developed in Japan and is being used there successfully for air conditioners and refrigerators. This technology is currently available only in split air conditioners.

Power Consumption of Inverter and non inverter air conditioners:

Based on data from BEE in 2018 (the levels are similar in 2020), the representative (median) sample of power consumption of Air Conditioners of various tonnage and star ratings is shown in Table 3.

	0.75 ton	1.0 ton	1.5 ton	2.0 Ton
1 Star AC (mostly non Inverter)	627	843	1246	1648
2 Star AC (mostly non Inverter)	596	1184	1184	1626
3 Star AC (mix of Inverter and non Inverter)	542	1104	1104	1448
4 Star (mostly Inverter)	464	945	945	1293
4 Star (mostly Inverter)	450	840	840	1113
	Annual Electricity Consumption (Units or kWh for 1600 hrs) based on data from BEE			

Table 3. star rating of air conditioner

V. CASE TUDY

For this work a 3BHK flat is taken as a case study as shown in fig 4

It is a residential 3bhk flat with overall 2 master bedrooms 1 hall 1 kitchen 1 balcony and 1 dining room and two washrooms with total

Energy estimation: The details of existing appliances and proposed energy efficient appliances is shown is Table 4 and Table 5 respectively.

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Figure 3. General 3Bhk flat characteristics

Table 4: Existing Appliances monthly Energy consumption chart:

Type of appliance	Power Watts	Total no	Usage hours/month	Energy consumption kWh/Month	Monthly expenditure @5/unit/INR)	Cost of Appliances (INR)
Fl light	36	6	300 hours (10 hrs per day)	64.8	324	900 (each 150)
Fan	90	5	300 hours (10 hrs per day)	135	675	6000 (each 1200)
Normal A/C	1800	2	150 hours (5 hrs per day)	540	2700	56000 (each 28000)
Refrigerator	500	1	360 hours (12 hrs per day)	180	900	15000
Total				919.5	4599	

Table:5 Proposed appliances monthly energy consumption chart:

Type of appliance	Power watts	Total no	Hours/Mo	Energy consumption kWh/Month	Monthly expenditure @5/unit/(INR)	Cost of appliances (INR)
LED light	18	6	300 hours (10 hrs per day)	32.4	162	2100 (each 350)
BLDC Fan	28	5	300 hours (10 hrs per day)	42	210	15000 (each 3000)
5 STAR Inverter AC	1000	2	150 hours (5 hrs per day)	300	1500	70000 (each 35000)
5 STAR Refrigerator	350	1	360 hours (12 hrs per day)	126	630	22000

Table :6 Monthly Savings and Pay back period

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VI. RESULTS

A. Monthly savings and payback period

The basic power requirement for the building was obtained from the energy audit. After the retrofit of energy efficient material's in the building. The total power is reduced to-500.4 kWh / day Cost is also reduced to 2502 Rs / month and the payback period is 63.9 months which is reasonable and affordabl

Appliance comparison	Energy Saving's (kWh/Month)	Electricity cost Saving per month (INR)	Cost of appliance Difference (INR)	Pay back period (months)
FL light	30.4	162	1200	7.4
LED				
Normal fan	93	465	9000	19.3
BLDC fan				
Normal AC	240	1200	14000	11.6
5 star inverter AC				
Normal Refrigerator	54	270	7000	25.9
5star Refrigerator				
Total	**417.4**	**2097**	**31200**	**63.9**