

## Energy Audit In Boys Hostel (Case Study Ali Hall)

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**Abstract**— Conservation and management of energy and power in any sector especially in large institutes, is of much significance. Energy efficient electrical systems lead to energy efficient delivering systems by keeping the power losses minimum. Energy audit is the best solution for the energy conservation where the system is verified and observed to reduce energy consumption without any negative effect on the system. It is an energy audit of a given case study of an accommodation area, a Boys Hostel (ALI Hall) of Bahauddin Zakariya University, Multan Pakistan. It is the comprehensive energy audit of hostel with tariff C-2b (29) T and 11.21 rupees per unit. Hostel is estimated as consuming 44836.42 units and cost of 502616 rupees. This survey and analysis suggests certain recommendations for energy savings and to reduce unit consumption up to 20098.572 and cost of 225305 rupees.

**Keywords**—Energy Audit, Consumption, Capital Cost, Payback Period, Savings

### I. INTRODUCTION

The energy use in the world is growing rapidly and this is causing supply deficiencies and heavy environmental disorders [1]. The issue of energy consumption and deficiency of energy is also increasing day by day in Pakistan. Pakistan is facing many energy problems. Generation of electricity is less as compare to the energy consumption. This is the cause of load shedding due to which our most of the sectors and industries are facing issues [2]. So, the need of today is to save and conserve energy. To achieve this public should be aware of energy audit and management system in order to save power. The most detailed method to analyze the energy usage and its wastage in an area or building is “ENERGY AUDIT” [3]. Energy audit is verification and analysis of use of energy including submission of a technical and official report containing recommendations for improving the efficiency of energy system with cost benefit analysis and the plan to decrease energy consumption. As Pakistan is facing energy crisis so energy audit is a fundamental way by which the system

can be supervised and improved. To stimulate energy consumption is a little bit tough job as it varies with the consumer’s goods and their operating duration. In this sense, there are some research techniques and approaches with some tools to estimate the energy performance of building. Energy management strategy and specially energy reduction can be done with energy [4-6]. Goals for energy management provide well organized strategies for calculated energy management [7].

### II. ENERGY AUDIT

An energy audit is an investigation, survey and analysis of energy flow for energy preservation or conservation in an industry or any other area of consideration and a mechanism to reduce amount of energy input to the system without any negative effect on output. Energy audit is analysis of how consumers use the energy [8, 9].

#### A. Steps of Energy Audit

Audit consists of following steps:

- Identification of whole energy system
- Analysis of the system (Electrically & Mechanically)
- Collection, observation, organization and analysis of the data
- Determination of cost reducing alternatives
- Analyzing the system on those alternatives
- Establishment of cost saving projects and their implementation
- Analysis of the findings and calculations and issue a report that outlines energy consumption and system improvement recommendations [10] [11].

According to the results of many surveys and researches it is concluded that a bulk of energy can be saved by energy audit.

### III. TYPES OF ENERGY AUDIT

There are three types of Energy Audit:

- Walk through Energy Audit
- Mini Energy Audit
- Comprehensive Energy Audit [4]

#### A. Walk through Energy Audit

This is also called preliminary or common Energy Audit. It is simplest type which is carried out in limited time with limited efforts. Its major focus is on the energy supply its demand and the user methods of conservation [12]. It includes activities related to collection, classification, calculation and analysis of available data for the establishment of energy consumption [13].

#### B. Mini Energy Audit

Mini energy audit is also called site energy audit. It actually expands the walk-through energy audit by collecting more information about facilities and performing a detail evaluation and calculation of energy consumption. Metering of a specific energy consumption sector is often a performed postscript of utility data.

#### C. Comprehensive Energy Audit

This is also called detailed energy audit. It is expansion of mini energy audit. It includes estimation of energy input for different sectors, collection of previous data on production level and specific energy consumption. This audit is a comprehensive account of energy use, including a quantitative and qualitative study of the implementation with detailed investments, functional and maintenance costs and an analysis. Not only the simple payback period is concerned but the life cycle cost parameters as interest rate, tax rate are also determined [10].

### IV. CASE STUDY

The case study considered here is the audit of Ali hall boy's hostel of Bahauddin Zakariya University. As university consists of thousands of consumers and appliances so it was provided with a bulk power or with 11KV feeder from WAPDA. University has its own distribution system for different departments, institutes, colleges, cafe, banks and hostels. The power cables and transformers are under the university not WAPDA. There are different tariffs of WAPDA for electricity distribution system. University has tariff C-2b (29) T. Ali hall is the boy's hostel in the university. It accommodates almost 510 students. Total 255 rooms are available in which 13 are for official use and rest of the rooms are for the students. The structure of hostel is described in the TABLE I.

|    |               |     |
|----|---------------|-----|
| 01 | Student room  | 242 |
| 02 | Washrooms     | 08  |
| 03 | Wings         | 16  |
| 04 | Crush hall    | 02  |
| 05 | Computer lab  | 01  |
| 06 | TV hall       | 01  |
| 07 | Mess hall     | 01  |
| 08 | Official room | 13  |

### V. METHODOLOGY

Energy management can be defined in terms of energy audit methodology as it is the strategy being used to adjust and optimize energy by using the methods and procedures to minimize energy requirements per unit of output. So, energy auditing is an effective tool to manage energy consumption in a given area. The methodology used in this case study is actually based on total energy consumption per month [14, 15].

The case study consists of three phases

Phase I - Pre-Audit Phase

Phase II - Audit Phase

Phase III - Post Audit Phase

### VI. POWER CONSUMPTION IN THE HOSTEL

Evaluation of data is also based on the participation of consumers towards the audit program. Lack of knowledge causes the consumers to respond them to high energy consumption and prices by taking involuntary cutbacks in their lifestyles [16, 17]. Most of energy is wasted at different levels. Wastage of energy is maximum in case of hostel due to lack of awareness and use of appliances that consume more power. In order to calculate total power consumption, a study of total running appliances and their power consumption is tabulated individually.

TABLE I. THE STRUCTURE OF ALI HALL

| Sr. N | Name of local | Number of locations |
|-------|---------------|---------------------|
|-------|---------------|---------------------|

TABLE II. ENERGY BILL OF EXISTING ELECTRIC SYSTEM IN ALI HALL

| Sr. No# | Name of appliances | Power ratings (W) | Usage time (Hours) | Power consumed per day (KW) | Power consumed per month ( KW) | Power consumed per year (KW) |
|---------|--------------------|-------------------|--------------------|-----------------------------|--------------------------------|------------------------------|
| 01      | Tube light         | 40                | 12                 | 0.48                        | 14.4                           | 175.2                        |
| 02      | CCTV camera        | 15.4              | 24                 | 0.36                        | 10.8                           | 131.4                        |
| 03      | Air conditioner    | 3500              | 06                 | 24                          | 720                            | 8760                         |
| 04      | Ceiling fan        | 75                | 15                 | 1.125                       | 33.75                          | 410.625                      |
| 05      | Electric kettle    | 3000              | 01                 | 03                          | 90                             | 1095                         |
| 06      | Oven               | 2150              | 03                 | 6.45                        | 193.5                          | 2354.25                      |
| 07      | Deep freezer       | 500               | 16                 | 08                          | 240                            | 2920                         |
| 08      | LCD (55 inch)      | 150               | 03                 | 0.45                        | 13.5                           | 160.25                       |
| 09      | Laptop charger     | 50-100            | 04                 | 0.28                        | 8.4                            | 102.2                        |
| 10      | Search light       | 500               | 10                 | 05                          | 150                            | 1825                         |
|         |                    | 400               | 10                 | 04                          | 120                            | 1460                         |
|         |                    | 100               | 10                 | 01                          | 30                             | 365                          |
|         |                    | 50                | 10                 | 0.5                         | 15                             | 82.5                         |
| 11      | Computer           | 30                | 03                 | 0.06                        | 1.8                            | 21.9                         |
| 12      | Iron               | 1000              | 01                 | 01                          | 30                             | 365                          |
| 13      | Electric cooler    | 70-100            | 24                 | 2.4                         | 72                             | 876                          |
| 14      | Internet router    | 5-15              | 24                 | 0.36                        | 10.8                           | 131.4                        |
| 15      | Air cooler         | 150               | 10                 | 1.5                         | 45                             | 547.5                        |

The cost per unit of electric power is Rs 11.21

TABLE III. ENERGY BILL OF ELECTRICITY SYSTEM IN ALI HALL

| Sr. No# | Equipment       | Energy consumed by an equipment (watts) | Energy consumed by an equipment (unit) | Total energy of an equipment per month (rupees) | Number of equipment | Total energy cost month (rupees) |
|---------|-----------------|---|--|---|---------------------|----------------------------------|
| 01      | Tube light      | 14400                                   | 14.4                                   | 161.4   | 720                 | 116225.28                        |
| 02      | CCTV camera     | 11088                                   | 11.08                                  | 124.207   | 19                  | 2359.929                         |
| 03      | Air conditioner | 720000                                  | 720                                    | 8071.2  | 01                  | 8071.2                           |
| 04      | Ceiling fan     | 33750                                   | 33.75                                  | 378.34  | 278                 | 105178.52                        |
| 05      | Electric kettle | 90000                                   | 90                                     | 1008.9  | 50                  | 50445                            |
| 06      | Oven            | 193500                                  | 193.5                                  | 2169  | 01                  | 2169                             |
| 07      | Deep freezer    | 240000                                  | 240                                    | 2690.4  | 02                  | 5380.8                           |
| 08      | LCD (55 inch)   | 13500                                   | 13.5                                   | 151.3   | 01                  | 151.3                            |
| 09      | Laptop charger  | 8400                                    | 8.4                                    | 94.16   | 150                 | 14124                            |

|    |                 |        |      |         |     |         |
|----|-----------------|--------|------|---------|-----|---------|
| 10 | Search light    | 150000 | 150  | 1681.5  | 14  | 23541   |
|    |                 | 120000 | 120  | 1345.2  | 7   | 9416.4  |
|    |                 | 30000  | 30   | 336.3   | 4   | 1345.2  |
|    |                 | 15000  | 15   | 168.15  | 1   | 168.15  |
| 11 | Computer        | 1800   | 1.8  | 20.2    | 07  | 141.4   |
| 12 | Iron            | 30000  | 30   | 336.3   | 100 | 33630   |
| 13 | Electric cooler | 72000  | 72   | 807.12  | 09  | 7264.08 |
| 14 | Internet router | 10800  | 10.8 | 121.068 | 16  | 1937    |
| 15 | Air Cooler      | 45000  | 45   | 504.45  | 240 | 121068  |

Total cost per month = Rs. 502616

#### A. QUANTIFICATION OF END USE

The loads were sequester based on the end use as lights and fans, air conditioners, computer/printers, hostel mess

cooking loads, electrical kettles and irons. Quantification and necessary measurements were carried out [18]. The details are given here [19]

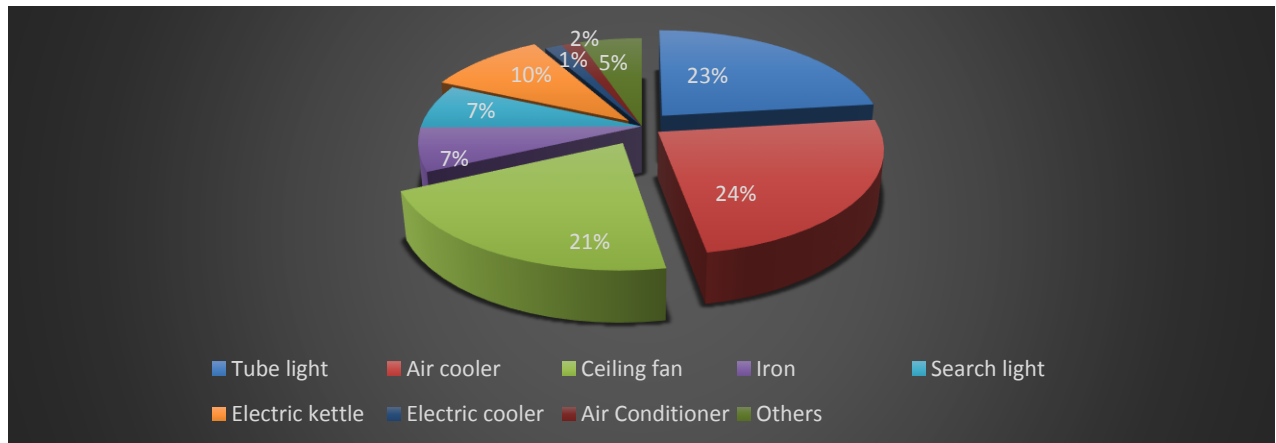


Figure 1. Quantification graph

#### VII. ENERGY AUDIT RECOMMENDATION

Energy management is a technique of fulfilling all the required energy demands. By using energy saving systems and optimizing strategies, energy consumption can be conserved to minimize the energy utilization per unit and its cost [20, 21]. Energy enhancing measures should not have only impact on energy consumption but also on all other such measures because in some cases they can conflict each other resulting an increment in energy consumption [22]. Energy Conservation Opportunities (ECOs) usually originate from energy providers or sources for example fossil fuels, electricity or alternating energy sources. For every end use equipment (transformers, geezers, fans, blowers, tube lights etc.) there exists an energy conservation opportunity.

ECOs give the potential trades off between initial costs, operating costs and life cycle of those equipment [23]. To invest in new energy saving mechanism is a risky task that it is uncertain about the long-term capital cost savings. Respondents across energy audit show some measures to reduce initial costs and for lower energy bills in a few years [17, 24]. Imperfect information like search or transaction cost is a barrier towards proper energy audit [25]. So, Energy Audit Recommendation is provided on the basis of capital cost and their payback periods. Detailed analysis of all the recommendations for reducing power consumption in hostel after assuming its capital cost is recommended here [26].

TABLE IV. RECOMMENDED POWER EQUIPMENT AND ENERGY BILL

| Sr. No# | Name of appliance | Recommended Appliances   | Power rating (Watt) | Usage time (Hour) | Power consumed per month (Watt) | Energy consumed by a equipment (unit) | Total energy cost of an equipment per month (rupees) | Number of equipment | Price    |
|---------|-------------------|--------------------------|---------------------|-------------------|---------------------------------|---------------------------------------|--|---------------------|----------|
| 01      | Tube light        | LED tube light           | 18                  | 12                | 6480                            | 6.48                                  | 72.64  | 720                 | 52300.8  |
| 02      | CCTV camera       | -                        | 15.4                | 24                | 11088                           | 11.088                                | 124.296  | 19                  | 2361.624 |
| 03      | Air conditioner   | DC converter             | 1470                | 6                 | 264600                          | 264.6                                 | 2966.17  | 01                  | 2966.17  |
| 04      | Ceiling fan       | Energy saver ceiling fan | 50                  | 15                | 22500                           | 22.5                                  | 252.225  | 278                 | 70118.55 |
| 05      | Electric kettle   | Energy efficient kettle  | 1200                | 1                 | 36000                           | 36                                    | 403.56   | 50                  | 20178    |
| 06      | Oven              | -                        | 2150                | 3                 | 193500                          | 193.5                                 | 2169.135   | 01                  | 2169.135 |
| 07      | Deep freezer      | Stand-alone deep freezer | 200                 | 16                | 96000                           | 96                                    | 1076.16  | 02                  | 2152.32  |
| 08      | LCD (55 inch)     | -                        | 150                 | 3                 | 13500                           | 13.5                                  | 151.335  | 01                  | 151.335  |
| 09      | Laptop charger    | -                        | 50-100              | 4                 | 8400                            | 8.4                                   | 94.164   | 150                 | 14124.6  |
| 10      | Search light      | LED Flood Light          | 100                 | 10                | 30000                           | 30                                    | 336.3  | 14                  | 4708.2   |
|         |                   | LED Flood Light          | 50                  | 10                | 15000                           | 15                                    | 168.15   | 7                   | 1177.05  |
|         |                   | LED Flood Light          | 10                  | 10                | 3000                            | 3                                     | 33.63  | 4                   | 134.52   |
|         |                   | LED Flood Light          | 10                  | 10                | 3000                            | 3                                     | 33.63  | 1                   | 33.63    |
| 11      | Computer          | -                        | 30                  | 3                 | 2700                            | 2.7                                   | 30.267   | 07                  | 211.869  |
| 12      | Iron              | -                        | 1000                | 1                 | 30000                           | 30                                    | 336.3  | 100                 | 33630    |
| 13      | Electric cooler   | -                        | 70-100              | 24                | 72000                           | 72                                    | 807.12   | 09                  | 7264.08  |
| 14      | Internet router   | -                        | 5-15                | 24                | 10800                           | 10.8                                  | 121.068  | 16                  | 1937.08  |
| 15      | Air Cooler        | DC air cooler            | 12                  | 10                | 3600                            | 3.6                                   | 40.356   | 240                 | 9685.44  |

**Total: Rs. 225305**

VIII. RECOMMENDATIONS FOR ENERGY CONSUMPTION OF ALI HALL

Energy management is an important tool to meet all the energy demands for the short-term survival and its long-term success [27]. Energy consumption is increasing day by day due to the expansion in built areas and its concerned energy needs. To control energy, some recommendations are provided to conserve energy by reducing energy consumption [1].

A. Replacing all Fluorescent Lights by LED Tube Lights

1) Reasons for Replacement

Fluorescent tube light is used in observation area (Ali hall) having electromagnetic ballast. The components of electromagnetic ballasts are usually a magnetic choke, a starter and a capacitor for power factor correction. Iron and copper losses in magnetic choke of ballast causes higher power losses

and poor power regulation. In short, fluorescent tube lights are not power saving equipment especially when it is working for 12 hours per day.

2) Recommendation

In our existing system, LED lights are recommended for fluorescent tube lights. In these LEDs, electromagnetic ballast is replaced by electronic ballast. These are more energy efficient (usually 10%-15%) than electromagnetic ballasts. So now it will not cause such amount of power losses as in the case of electromagnetic ballasts. It permits to deliver constant supply of power to load during its entire useful life. These LEDs work on 18 Watt dissimilar to Tube lights which were consuming 40 Watt [4]. Energy can be saved in Lighting system by reducing their illumination levels, changing its operating hours, improving their efficiency and taking the benefit of day light.

Table V. COMPARISON

| EXISTING SYSTEM                                       |                                 | RECOMMENDED SYSTEM  |                                |
|---|---------------------------------|---|--------------------------------|
| Total number of rooms                                 | = 255                           | Total number of rooms   | = 255                          |
| Total number of tube lights in rooms                  | = 720                           | Total number of tube lights in rooms                          | = 720                          |
| Total watts consumed                                  | =720*40<br>=28800W              | Total watts consumed  | =720*18<br>=12960W             |
| Total usage time/day                                  | =12 hours                       | Total usage time/day  | =12 hours                      |
| Total usage time in a year                            | =12*365<br>=4380 hours          | Total usage time in a year                                    | =12*365<br>=4380 hours         |
| Total watts in a year                                 | =28800*12*365<br>=126144000     | Total watts in a year   | =12960*12*365<br>=56764800     |
| Total units in a year                                 | =126144                         | Total units in a year   | =56764.8                       |
| Cost of 1 unit  | =RS 11.21                       | Cost of 1 unit  | =RS 11.21                      |
| Total cost in a year                                  | =126144*11.21<br>=Rs 1414074.24 | Total cost in a year  | =56764.8*11.21<br>=Rs 636333.4 |
| <b>Total Savings</b>                                  |                                 |   |                                |
| Saved unit of power                                   |                                 | = 126144-56764.8<br>= 69379.2 units                           |                                |
| Saved money   |                                 | = 1414074.24-636333.4<br>= RS 777740.8                        |                                |
| Total investment                                      |                                 | =720*550<br>=RS 396000<br>= (396000/777740.8) *12<br>6 months |                                |
| We can regain the led tube light cost within 6 months |                                 |   |                                |

There are some steps should be taken to conserve energy from lighting system:

Use of natural day light should be maximum Compact fluorescent lights should be used instead of incandescent fluorescent light. The circuits controlling the lighting should be separate from other circuits [28].

**B. Replacing All Fans by Energy Saving Ceiling Fan (Royal Company)**

*1) Reasons for Replacement*

A fan is one of the major contributions in energy consumption in house hold as well as in hostels. The fans used in our existing systems are AC induction motor fans which approximately rate from 60-75 Watt. These motors are less efficient and are heavier providing maximum efficiency of 50%. All the motors should be energy efficient [29]. Normally power rating of ceiling fan at different regulations is given as [4]

|         |      |      |      |      |      |
|---------|------|------|------|------|------|
| Speed   | 1    | 2    | 3    | 4    | 5    |
| Wattage | 14 W | 26 W | 39 W | 48 W | 76 W |

*2) Recommendation*

To save energy, ceiling fans are recommended to replace the present ones by Royal Fans which

consumes 50 watts not 75 watts. Re lubricate all the grease fitting and belt driven units of wheel shaft bearings after each three year. Every three to five (3-5) years, lubrication of pre-lubricated motors is needed. Belt tension should be checked every 6 months. Out of balance running of motor

can be caused by blade damage or due to blower blades. So, check all these on regular basis [23].

TABLE VI. COMPARISON

| EXISTING SYSTEM                                    |                                   | RECOMMENDED SYSTEM  |                             |
|--|-----------------------------------|---|-----------------------------|
| Total number of rooms                              | = 255                             | Total number of rooms   | = 255                       |
| Total number of fans in rooms                      | = 278                             | Total number of fans in rooms                                       | = 278                       |
| Total watts consumed                               | =278*75<br>=20850W                | Total watts consumed  | =278*50<br>=13900W          |
| Total usage time/day                               | =15 hours                         | Total usage time/day  | =15 hours                   |
| Total usage time in a year                         | =15*365<br>=5475 hours            | Total usage time in a year  | =15*365<br>=5475 hours      |
| Total watts in a year                              | =20850*15*365<br>=114153750       | Total watts in a year   | =13900*15*365<br>=76102500  |
| Total units in a year                              | =114153.75                        | Total units in a year   | =76102.5                    |
| Cost of 1 unit                                     | =RS 11.21                         | Cost of 1 unit  | =RS 11.21                   |
| Total cost in a year                               | =114153.75*11.21<br>=RS 1279663.5 | Total cost in a year  | =76102.5*11.21<br>=RS853109 |
| <b>Total saving</b>                                |                                   |   |                             |
| Saved unit of power                                |                                   | = 114153.75-76102.5<br>=38051.25 units                              |                             |
| Saved money  |                                   | =1279663.5-853109<br>= RS426554.5                                   |                             |
| Total investment                                   |                                   | = 278*2900<br>= RS 806200<br>= (806200/426554.5) *12<br>= 23 months |                             |
| We can regain the ceiling fan cost within 23months |                                   |   |                             |

TABLE VII. REPLACING AC AIR COOLER BY DC AIR COOLER (USING CONVERTER)

| EXISTING SYSTEM             |                               | RECOMMENDED SYSTEM          |                           |
|-----------------------------|-------------------------------|-----------------------------|---------------------------|
| Total number of Air coolers | = 240                         | Total number of Air coolers | = 240                     |
| Total watts consumed        | = 240*150<br>= 36000W         | Total watts consumed        | = 240*12<br>= 2880W       |
| Total usage timing/day      | = 10 hours                    | Total usage timing/day      | = 10 hours                |
| Total usage time annually   | = 10*365<br>= 3650 hours      | Total usage time annually   | = 10*365<br>= 3650 hours  |
| Total watts annually        | = 36000*10*365<br>= 131400000 | Total watts annually        | = 2880*3650<br>= 10512000 |
| Total units annually        | = 131400                      | Total units annually        | = 10512                   |
| Cost of 1 unit              | =RS 11.21                     | Cost of 1 unit              | = RS 11.21                |
| Total cost annually         | = 131400*11.21                | Total cost annually         | = 10512*11.21             |

|   |              |                                     |             |
|---|--------------|-------------------------------------|-------------|
|   | = RS 1472994 |                                     | = RS 117840 |
| <b>Total Saving</b>                     |              |                                     |             |
| Saved unit of power                     |              | = 131400-10512                      |             |
|   |              | = 120888                            |             |
| Saved money                             |              | = 1472994-117840                    |             |
|   |              | = RS 1355154                        |             |
| Total Investment                        |              | = 240*5000                          |             |
|   |              | = RS 1200000                        |             |
|   |              | = (1200000/1355154) *12 = 10 months |             |
| We can regain the cost within 10 months |              |                                     |             |

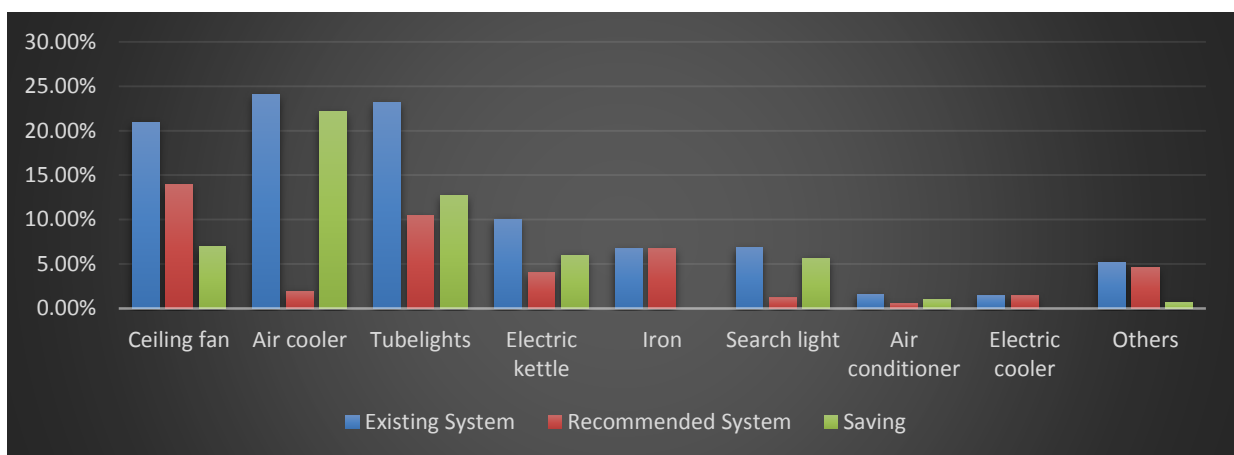


Figure 2. Comparison chart

### CONCLUSION

By the procedure of energy audit, total 24737.848 units are saved. The energy cost is reduced from 502616 rupees to 225305 rupees per month. Energy audit is a powerful technique to examine and solve the energy deficiency and consumption problems. On monthly basis, energy can be conserved annually by ding the more power consuming equipment due to their poor efficiency. By recommending efficient and less power consuming devices, energy cost can be reduced. This way is counted as the proper authentic way to reduce energy losses. If such audit is conducted for the whole institute i.e. Bahauddin Zakariya Univeristy, then more energy can be conserved.

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