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Energy Audit: A Case Study of UET Jalozai Campus

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***Abstract*—** Pakistan is facing a decade long worst crises of energy. The demand supply gaps, heavy dependence on imported fossil fuel and inefficient consumption patterns are major thematic reasons of crises. Energy conservation is a low hanging fruits which can be materialized to answer the crises. This is a joint academia and industry projects, where detailed energy audit of educational facility of University of Engineering and Technology Jalozai Campus was carried. The significant energy consumer areas of educational building like lighting, Heating and cooling system and generation plants were deeply investigated. In additions, the male and female boarding houses were audited. Based on Illumination Engineering Standards and ASHRAE level III benchmarking, various energy conservations measures were recommended including efficient lighting system, installation of occupancy sensors, office appliances scheduling and transition towards energy efficient fans. The suggested recommendations implementations are capable to save a 22.3% of electricity in the facility. The economic analysis shows a payback period six to eighteen months for various conservation measures. In addition, a behavioral training and mobilization drive is highly recommended to build the conservation culture on gross root level as integrated part of societal practices and cultural values.

***Keywords*—** Energy Audit, Energy, Lux Meter, Lighting, Generation, Consumption

I. INTRODUCTION

The concept of energy conservation becomes popular during Arab Oil embargo of 1970 and further highlighted during recent focus on sustainability. The global agenda of sustainable development emphasize equally on energy access and energy conservation. On one hand, technological research is focused on efficiency targets whereas on other energy audit is utilized to save energy in existing facilities. Energy Audit is basically the inspection, monitoring and analysis of energy flow, for the energy conservation of domestic, industrial or commercial facility, to minimize the energy consumption of the system.

China is at the top having highest energy consumption growth rate of 5.5% per year followed by United States consuming 25% of the world total energy. Industrial sector is the top consumer accounting 37% of the world total energy consumption [1]. The total energy consumption in industrial sector in 2006 was 51,275ZW and it is expected to rises up to 71,961ZW in 2030 with an annual growth of 1.4% [1, 2]. In US 33% of the total energy is used by industries where as in china, according to the data available for 2003, 70% of the total energy is used by the industrial sector with an annual growth of 5% which is five times more than the normal growth. Only China alone is accounting for 23% of the world total industrial energy consumption [1, 2].

Pakistan energy demand is rapidly increasing because of urbanization and industrialization. Pakistan primary energy supply in the financial year 2017 was 92.9 MTOE [3]. It consists of 47.5% of natural gas, 30.5% of oil, and 10.9% of hydel, 9.2% of coal,1.2% nuclear and 0.7% LPG [3]. In the coming fifteen years the demand will increase to 122 MTOE, thus increasing the annual energy import bill to more than US $41 billion compared to the total current annual energy import bill of US $7.5 billion in 2008 [4]. To meet this galloping energy demand is a herculean task for the government. In Pakistan 43% of the total annual energy consumption is used by industry, 29% by transportation, 20% by domestic and 8% by others [4,5].

In 2011, Energy Conservation Centre (ENERCON) prepared the first national policy for energy conservation. They find that Pakistan need to improve the existing system taking Energy Conservation Measures (ECM) in various areas like power transmission and distribution, load management, power plants, and more importantly the end user. Overall saving of 25% of the total industrial consumption can be achieved through energy auditing. For financial year 2008, a saving of 8.4 MTOE was estimated which is approximately 15% of the total primary energy consumption [6]. It is forecasted that electricity and natural gas saved through continuous energy auditing and conservation is equal to the generation capacity of 3710 MW and 3060 MW correspondingly [6,7]. A total reduction of 51% in the annual fuel import is estimated. However there are many barriers to energy auditing and conservation such as lack of knowledge, management, policy and financial resources. According to report of SAARC a total investment of US $ 8.16 billion is required for energy efficiency sector from 2010-2019 in Pakistan [4].

A report from USAID office of energy , environment and technology entitled “Prompting energy efficiency in the reforming electricity market” has assessed the energy

efficiency potential in developing and reconstructing countries and come up with the following informative conclusions [6];

1. Energy efficiency has the potential to reduce total forecast demand for power in said countries by 5% to 10%, equivalent to 220 – 440 GW new installed capacity and 1000 – 2000 billion kwh/year.
2. Energy efficiency measures cost less than half that of new supply, equivalent to;
    - Initial cost saving of at least $140 -280 billion in capital investments
    - Significant saving's in avoided operating costs

According to International Environmental Agency (IEA) 5% of emission of the world is taking place from steel and iron industry. US are the third largest steel making country with a production of 80.5 million tons in 2010 [1].A research for reducing energy consumption and carbon dioxide emissions in US steel and iron sector was carried proposing three different scenarios to achieve 20% reduction in annual emission. These scenarios are; investment in national energy efficiency measures, energy efficiency measures along with commodity trading with china and India and energy efficiency measures along with carbon trading with and India [6].

University of Engineering and Technology, Peshawar (UET-P) is one of the prominent institutes of Khyber Pakhtunkhwa. University of Engineering and Technology Jalozai is a campus of UET-P located southward on Pabbi-Cherat road at 12 Km from main Grand Truck road of district Nowshera. The campus total is spreader over an area is 402 acres whereas covered areas with educational facility is about 1021,233 sq.ft. Currently the campus includes Electrical, Civil, Mechanical and Industrial department's blocks and three hostels.

II. METHODOLOGY

This section describes the instrumentation and measurement techniques relevant to energy audit activities. An energy auditor must have a basic understanding of measurement techniques and instrumentation in order to be knowledgeable about the purchase or rental and use of the equipment [9,10]. Both the correct instrument and its correct use are fundamental requirements for obtaining useful measured data[15].

The auditor's Toolbox

The following sections include details of the instruments commonly found in the energy auditor's toolbox:

- Electric power meter
- Combustion analyzer
- Digital thermometer
- Infrared thermometer
- Psychomotor (humidity measurement)
- Airflow measurement devices
- Tachometer
- Ultrasonic leak detector
- Lux meter

Instruments used during Audit in UET Jalozai

The following are the instruments used during audit in University of Engineering and Technology Jalozai campus.

- Lux Meter
- Clamp meter
- Power factor meter
- Power quality manager
- Digital Millimeter
- Temperature Indicators

Energy Audit Methodology

Three steps to be taken for the energy audit methodology.

Data collection:

The first step of the energy audit is data collection. Different type of tools is used in the comprehensive data collection such as measurement, observation and interrogati ng the crucial persons [11,12].

Detail analysis:

The second step is the detail analysis of the energy audit where diverse instruments are used for extensive analysis of energy flow in the buildings [13].

Recommendations:

Based on real time analysis of energy flows, various energy conservation measures are recommended to optimize energy consumption patterns of the facility.

Energy audit of lighting and cooling system:

Lighting is providing in the indoor, outdoor, commercial building, industries for the relaxed working environment. The main objectives are to deliver essential lighting for the final installed load for example maximum lighting at the lowest power consumption[14,16].

Purpose of the Performance Test:

Most of the lights required in interior for meeting normal luminance of the horizontal plane, either through the inside or in the exact area within the interior share with common lighting of its lower value.

Main purpose of this test is to analyze the installed valve in terms of lux/watt/m² for the installation of common lights.

Lumen:

Lumen is the unit of light flow. The total lights production of the lamp is measure the lumen rating. General measurement of light output is lumen.

Lux:

Lux is the unit to measure the luminance of the surface. One lux is equal to the one lumen per square meter.

Circuit Watt:

The circuit watt is the total power drawn by the lamp in a lighting circuit underassessment.

Installed Load Efficacy:

Installed load effectiveness is to provide maintained average illuminance on the horizontal plane per circuit watt with the interior of general lighting. Unit: lux per watt per square meter (lux/W/m²)

Lamp Circuit Efficacy:

Amount of light emitted by the lamp for each watt of the power consumed by the lamp circuit. For example control gear losses. This is the meaningful measurement for those lamp that need the control gear.

Lighting System:

The hostel and departments was segmented into many sub groups which utilizes lighting system. These include the Offices, Class Room, Staff Room, Resident Rooms, Warden Lodges, Mosques, Washrooms, Mess and canteen, Common room, Study room, Corridors, Lounges.

The fixtures in this area include compact fluorescent light (CFL), Incandescent bulb and fluorescent fixture of varying size. Below Table I and Table II shows the properties of lights and recommendations and light level for different work space

TABLE I. TABLE 1: PROPERTIES OF LIGHTING APPLIANCES (IES-2010)

Lamp Type	Lumen Output (initial)	Lumen Output (maintained)	Burning Life Hours
Light Emitting Diode (LED)	150 +	150 +	60,000 +
Low-Pressure Sodium (LPS)	147	147	10,000
High-Pressure Sodium (Clear) (HPS)	105	77	12,000
Pulse Start Metal Halide (MH)	98	59	6,000
Standard Metal Halide (MH)	96	60	6,000
T8 Fluorescent (FL)	93	84	7,500
Induction Fluorescent (Sylvania Icetron) (IFL)	83	62	10,000
T12 High-Output (800 ma) Fluorescent (FL)	79	64	7,500
T12 Cool-White Fluorescent (FL)	74	59	7,500
Compact Fluorescent (PL)	68	54	5,000
Tungsten Halogen (Quartz) (TH)	19	17	2,000
Incandescent (standard) (INC)	14	12	1,000

TABLE II. TABLE 2: RECOMMENDATIONS AND LIGHT LEVEL FOR DIFFERENT WORK SPACE (IES-2010)

Activity	Illumination (lux, lumen/m2)
Public areas with dark surroundings	20 - 50
Simple orientation for short visits	50 - 100
Working areas where visual tasks are only occasionally performed	100 - 150
Warehouses, Homes, Theaters, Archives	150
Easy Office Work, Classes	250
Normal Office Work, PC Work, Study Library, Groceries, Show Rooms, Laboratories	500
Supermarkets, Mechanical Workshops, Office Landscapes	750
Normal Drawing Work, Detailed Mechanical Workshops, Operation Theatres	1,000
Detailed Drawing Work, Very Detailed Mechanical Works	1,500 - 2,000
Performance of visual tasks of low contrast and very small size for prolonged periods of time	2,000 - 5,000
Performance of very prolonged and exacting visual tasks	5,000 - 10,000
Performance of very special visual tasks of extremely low contrast and small size	10,000 - 20,000

III. RESULTS AND DISCUSSION

This section delineates the results of the energy audit activities undertaken during the course of the research. This section is organized such that the current energy consumption for the utility supplied electricity and gasoline generator electricity for all the buildings i.e. the three hostels, Civil Engineering department and the Electrical energy department is presented. Following this the same results are simulated while retrofitting low energy consumptive technology. The overall energy consumption for the aforementioned buildings using utility power is given in the table III, detailing the energy used in lighting, cooling and miscellaneous electricity consumption equipment. Figure 1 gives the percent consumption of the energy in the lighting, cooling, and miscellaneous sources.

TABLE III. TABLE 3 TOTAL POWER CONSUMPTION THROUGH ELECTRICITY

Lightening power consumption KWH/Year	172668.2
Fans and cooling power consumption KWH/Year	184116.6
Miscellaneous Power consumption KWH/year	174600
Total Power Consumption KWH/year	531384.8

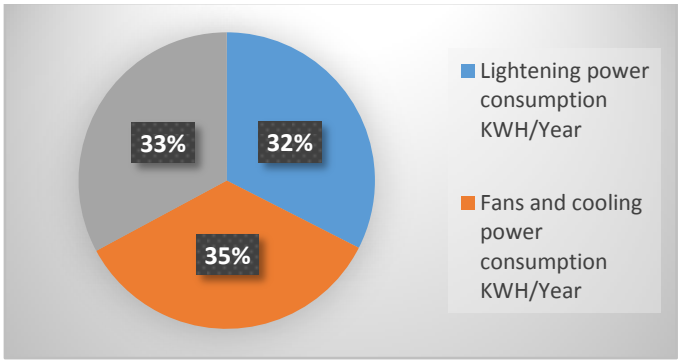

Figure 1. Percentage of total power consumption of electricity

Total power consumed by the hostel and departments for the session 2017-18 using gasoline in generator as a power source is 542049.12 KWH/year. In which major contribution to power consumption is by the cooling system 201892.32 KWH/year as shown in the Table IV.

TABLE IV. TOTAL POWER CONSUMPTION THROUGH GENERATOR

Lightening power consumption KWH/Year	167836.8
Fans and cooling power consumption KWH/Year	201892.3
Miscellaneous Power consumption KWH/year	172320
Total Power Consumption KWH/year	542049.1

Accordingly the percent energy consumption for each of the three mentioned sources i.e. cooling, lighting, and miscellaneous sources is given in the pie chart in Figure 2.

Figure 2. Retrofit of Lighting suggestions

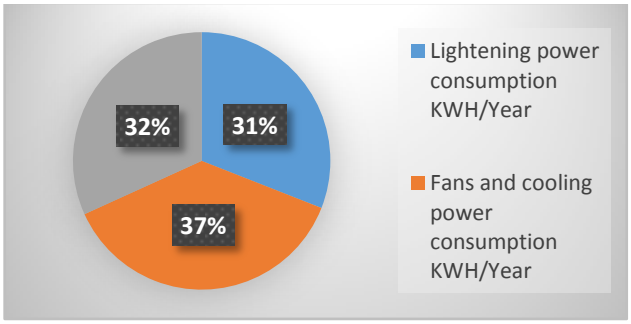

Figure 3. Percentage of total power consumption of Gasoline

The departments' and hostels' lighting system consist of fluorescent tubes, incandescent bulb and mostly CFL. We have suggested retrofitting according to figure 3 given below.

Similarly alternative less energy intensive suggestions have been made for cooling and miscellaneous energy consumption equipment as shown in the figures 4 and 5.

Figure 4. Retrofit of Fans

In addition Use of sensors for automatic lighting control system in washrooms, corridors, staff rooms and in offices to control and detect the actual requirements of lights[17]. It was also recommended to switch off the lights in unused area by installing automatic sensors and control system to save sustainable amount of energy.

Based on the recommended retrofitting appliances and sensor placement the simulation shows savings in energy consumption and pursuant capital savings for both the gasoline generator electricity consumption and the utility energy consumptions. The results from the retrofitting of appliances is given in the form of energy and capital savings as shown in the Tables V and Table VI for the utility and gasoline electricity provision respectively.

TABLE V. FISCAL SAVINGS FROM RETROFITTING APPLIANCES FOR UTILITY ELECTRICITY

Total Saving from electricity as source for replaced lights in KWH/Year	91601.84
Total saving from electricity as source replaced for fans in KWH/Year	217851.2
Total energy saving from electricity KWH/year	309453
PKR/KWH	15.5
Saved amount PKR/year	4796522

TABLE VI. FISCAL SAVINGS FROM RETROFITTING APPLIANCES FOR GASOLINE ELECTRICITY

Total saving from generator as source for replaced lights in KWH/year	86601.34
Total saving from generator as source for fan in KWH/year	26995.20
Total energy saving from generator as resource KWH/year	113596.54
Total saving from generator as resource MJ/year	408947.54
Conversion factor MJ/liter of Gasoline	35.00
Total gasoline used liters/year	11684.22
PKR/liter of gasoline	100.00
Total amount saved PKR/year	1168421.55

The overall amount saved through energy audit from both energy resources is PKR 5964943.674. The overall amount distribution is given in the table VII below.

TABLE VII. THE OVERALL AMOUNT DISTRIBUTION

Total saving from electricity PKR/year	Total saving from Gasoline PKR/year	Overall saving PKR/year
4796522.12	1168421.554	5964943.674

These results are only from the two engineering departments and three hostels. The whole of university could also be audited to give a more detailed analysis and more capital saving could be achieved.

CONCUSLION

The energy audit of a large buildings can allow national level analyses and considerations on the strategies for a smart planning of improvements. This research identified key energy efficiency improvement areas in a university in KP, Pakistan. The significant energy usage areas were identified in form of lighting, cooling/heating and other miscellaneous energy consumption appliances. The energy bills of the university, especially the gasoline consumption charges in times of load shedding from national utility have been significantly high. This research identified areas for improvement and recommended alternative appliances with lower energy intensity and the simulation of energy consumption with these appliances would prove extremely beneficial in terms of energy bills and environment. Overall the recommended energy appliances will result in benefit of PKR 5964943.674.

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REFERENCES

[1] U.S Energy Information Administration. International Energy Outlook 2009: World Energy and economic Outlook; 2009,

[2] United Nations Industrial Development Organization (UNIDO). Policies for promoting industrial energy efficiency in developing countries and transitioneconomies; 2008

[3] Hydro Carbon Development Institute (HDIP), Pakistan Energy Year Book, 2017

[4] SAARC Road Map For Energy Conservation And Energy Efficiency In Pakistan

[5] Abdul Raheem et. Al, Renewable energy deployment to combat energy crisis in Pakistan , Energy, Sustainability and Society ,2016

[6] ENERCON, Pakistan Energy Conservation Potentials, 2014

[7] Energy conservation and emission reduction through electric motors in industrial sector of pakistan. Sindh University Research Journal - SURJ (Science Series), [S.l.], v. 46, n. 1, mar. 2014. ISSN 1813-1743. Available at: <http://sujo.usindh.edu.pk/index.php/SURJ/article/view/1818>. Date accessed: 15 April 2019.

[8] USAID Energy Efficeny Initivitaie Prompting energy efficiency in the reforming electricity market, 2013

[9] Kim, H.Y.; Kang, H.J. A Study on Development of a Cost Optimal and Energy Saving Building Model: Focused on Industrial Building. Energies 2016, 9, 181.

[10] Hu, M. Cost-Effective Options for the Renovation of an Existing Education Building toward the Nearly Net-Zero Energy Goal—Life-Cycle Cost Analysis. Sustainability 2019, 11, 2444.

[11] Hinge, A.; Bertoldi, P.; Waide, P. Comparing commercial building energy use around the world. In Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA, USA, 22–27 August 2004.

[12] Aljami, A. Energy audit of an educational building in a hot summer climate. Energy Build. 2012, 47, 122–130.

[13] Desideri, U.; Leonardi, D.; Arcioni, L.; Sdringola, P. European project Educa-RUE: An example of energy efficiency paths in educational buildings. Appl. Energy 2012, 97, 384–395.

[14] Bourdeau, M.; Guo, X.; Nefzaoui, E. Buildings energy

[15] consumption generation gap: A post-occupancy assessment in a case study of three higher education buildings. Energy Build. 2018, 159, 600–611.

[16] Lin, B.; Zhang, Z.; Ge, F. Energy Conservation in China's Cement Industry. Sustainability 2017, 9, 668.

[17] Zhu, P., Gilbride, M., Yan, D. et al. Build. Simul. (2017) 10: 799 https://doi.org/10.1007/s12273-017-0408-6

[18] Thollander, P.; Danestig, M.; Rohdin, P. Energy policies for increased industrial energy efficiency: Evaluation of a local energy programme for manufacturing SMEs. Energy Policy 2007, 35, 5774–5783.

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