ENERGY EFFICIENCY RESOURCE ASSESSMENT AND OPTIMIZATION AT UNIVERSITY OF ENGINEERING AND TECHNOLOGY

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Abstract: *This research is the summary of energy usage in UET Peshawar located in Peshawar, Pakistan. Electricity and natural gas are the main consumers of energy in university. About 90 percent of energy is consumed by electric equipment and 10 percent of energy is consumed in gas heaters. Here audit of electric energy consumption is conducted. Electrical energy is consumed by lights, fans and air conditioners. The purpose of energy audit is to provide energy use analysis, and to identify energy conservation measures to reduce energy consumption and operating cost. The scope of research work includes a detailed survey of electric energy cost and consumption per year. The recommended energy conservation measures show technically and economically feasible opportunity to increase energy efficiency of university and reduce the energy and operating cost. In this Energy audit research work several preliminary measures are reported which if implemented will save energy cost of estimated annually. To achieve the estimated savings, initial investment of 69,659,453 PKR must be done to achieve estimated savings of 19,870,359 PKR annually, with energy savings of 907,696 kWh per year. Among these ECMS light retrofitting is very feasible because its payback is less than year. And it saves 2,491,225 PKR annually. The remaining energy conservation measures needs discussion with the administration as the savings is huge, but their initial investment is also high.*

Key Words: Energy Audit, Energy Conservation Measures, Energy Consumption, Electric Equipment, Savings

1. INTRODUCTION

The task of powering clean energy can be achieved by taking aggressive steps to improve energy efficiency in universities. Huge amount of energy is used in universities. Energy efficiency measures can reduce bills up to 5 to 10 percent. Energy efficiency measures are the cheapest option to meet the increasing energy needs and associated emissions. Many solutions are available today and must be deployed quickly.

In Pakistan, many Universities have old buildings that are not either designed to be energy efficient or have outdated equipment. By improving energy efficiency, University can save money, reduce campus carbon footprint, and demonstrate environmental leadership.

Universities can make cost effective investments to improve energy performance by introducing energy saving LEDs, efficient motors and undertake building retrofits to improve insulation and upgrade cooling and heating equipment.

In general, energy is used in the form of electricity used for lighting, computers, air conditioners, motors, and fans. Natural gas is used in winter for heating purposes.

The conservation of energy is an essential step to overcome the energy crises and the increasing environmental degradation due to greenhouse gas emissions. Developing as well as developed countries are interested to increase awareness of inefficient power generation and inefficient energy usage. However usually less information sources are available in the rational use of energy. The rational use of energy calls for a broad application of energy conservation technology in various sectors where energy is wasted. One of them is University campuses which pay huge bills for energy each year. Their energy consumption can be reduced by introducing modern energy conservation technology.

Throughout the universities, building managers and facility departments are saving money and cutting emissions by reducing campus building energy use. Increasingly these teams are achieving deeper reductions by implementing innovative energy efficiency measures and undertaking ongoing commissioning projects to optimize building performances.

Ninety-seven present of building emissions are from building electricity use, heating and cooling. Harvard focused on increasing the energy efficiency of more than 600 buildings. As a result, building energy use was down 7 percent across the University, even as the campus energy use grew each year. Total building energy use was reduced ten percent in the same time (Heike-Erhorn-Klutgg).

The Leuphana University Luneburg consists of 25 buildings constructed in different periods. The reduced their energy consumption of building stock by 30% delivered energy and 50% primary energy. The specific energy improvement measures include the optimization of heating circuits, the shut of local heating system in summer, new meters and efficient pumps as well as LED efficient lighting and singe room control (Heike-Erhorn-Klutgg).

The University complex of TU Braunschweig consists of 136 buildings. The project ran from 2012 to 2016 focusing on the development of energy efficiency roadmap for the whole campus with defined targets for 2020 (reduction of primary energy use up to 40%). The foreseen energy savings include the improvement of building envelope, the replacement of lighting system in traffic areas, labs and offices, the optimization of the operation of air-conditioning and ventilation system. So far the primary energy use of the University based on measured delivered energy reduced from 293 kWh/m^2 in 2012 to 238 kWh/m^2 in 2015.This translates to the reduction of nearly 20 % of the primary energy by 2015 (Heike-Erhorn-Klutgg).

The Lucia building of University of the University of Valladolid is zero CO_2 emission and zero energy building using passive and bioclimatic design strategies. Due to management and production of autonomous local renewable energy, the building has received LEED PLATINUM level certification. The façade includes overhangs providing self-shadowing effect in the summer, reducing the cooling load while providing the natural light. Considering the building location, the U-values of the façade (0.17W/m^2.ºK) and roof (0.15W/m^2.ºK) are very low, leading to the low transmission loses (Waqas Ahmad Mahar,Naved ur Rehman Anwar,Shady Atia, 2018). The insulation material is based on wood. Solar tubes are providing natural lighting indoor and digital addressable lighting interface is used as lighting control system. Heating and cooling are provided by geothermal pipes. Together with the façade integrated PV and a biomass combined heat and power system, the energy use is 100% renewable (Heike-Erhorn-Klutgg).

The Edge is new office building ZuidAs in University of Amsterdam. The building has achieved BREEM green building certification score of 98.4%. The building uses information technology to shape the way people work and to maximize the comfort and energy efficiency in building spaces. The building adapts to the user preferences for lighting and heating via mobile app. Solar panels in the south side of the building are used for shading the offices and for generating the electricity. Sustainable highlights include a smart lighting system, energy generation from 5,900 m2 PV panels providing heating energy via an aquifer thermal energy storage and electricity powering all smart phones, laptops and electric cars. These features make the building a net zero-energy building showcase (Heike-Erhorn-Klutgg).

In 2011 Allegheny college joined the US department of energy better buildings challenge committed to reduce building energy intensity by 20% by 2020. Since then, the Allegheny college has reduced energy intensity up to 15%. One project, a renovation of car hall to make room for Allegheny college growing environmental science department made the building 23% more efficient through improvement that is better heat recovery and efficient lighting system (Heike-Erhorn-Klutgg).

Georgetown makes a commitment to energy efficiency and conservation across campus. The efficiency and conservation measures George Town has invested in since FY14 save at least 3.3-million-kilowatt hour of electricity and 82,000 million btu of gas annually and also cutting CO_2 emission equivalently taking 12,000 cars off the road (Heike-Erhorn-Klutgg).

2. ENERGY EFFICIENCY AND GREENHOUSE GAS EMISSIONS

The environmental impact of building is staggering. Environmental pollution occurs in all parts of university from laboratories to administration offices. Universities used extensive energy and with less efficiency having high greenhouse gas emissions. In Europe buildings account for 40% of total energy use and 36% of total CO_2 emissions (Milad Mohammadalizadehkorde , Russell Weaver, 2018). Globally buildings were responsible for 35% to 45% of the global energy consumption in 2010. Along these lines, buildings are spaces where energy savings innovation have the potential to make substantial positive environmental impacts.

Among higher education institutions they have expressed interest in enhancing building energy performance. Idea of green building has varied across universities and regions based on factors like climate and primary use. Commonly green buildings are those that include mechanisms for decreasing waste and hazardous material while demanding fewer resources. Data on energy consumption trends produced by international energy agency show that during two decades from 1984-2004, primary energy use grew by 49% and CO_2 emissions by 43% with an annual increase of 2% and 1.8% respectively (Milad Mohammadalizadehkorde , Russell Weaver, 2018).

Studies show that improving energy efficiency is the direct mean of reducing greenhouse gas em96issions (Mohsen Ms,Akash BA, 1998). Energy efficiency serves as an important function in reducing fossil fuel energy consumption, which in turn can reduce air pollution. Little or no investments are needed for reducing 10-30% reduction in greenhouse gas emissions (Saidur, R., Rahim, N.A., Ping, H.W., Jahirul, M.I., Mekhilef, S., Masjuki, 2009).

Types of Energy Used in University

Generally, two types of energy are used in university:

1. Electricity
2. Natural gas

Electricity is used as a common power source for all equipment, cooling system, lighting, computers, lab equipment etc. Natural gas is used for heating during winter.

3. METHODOLOGY

Literature Review

This is first and important step for research. A detailed and thorough study literature study was conducted to completely understand the energy efficiency system of different Universities. New technology especially in lighting system were studied and their efficiency was studied. LED and energy saver efficiency are studied and their lumens per watt was studied. Efficient and inefficient motor were studied. and replacement cost of these inefficient equipment's with efficient equipment and their simple payback period were studied. Energy conservation measures adopted in different Universities of the world were thoroughly studied. And how they implemented these technologies and what are the hurdles in implementing these measures.

Site Visit and Data Collection

Data was collected through walk through audit. Incandescent Bulbs, compact florescent lamps, compact fluorescent tube light were counted in labs, office's classrooms and their wattage were noted from their name plate. Ceiling, exhaust and bracket fan were counted, and their wattage was noted. Data sheets of lighting, fan and air conditioning system was filled. Ton and input power of air conditions were noted from there name plate and sheet was filled.

Data Analysis

The data was taken only from electrical department. The data was extrapolated for all other departments. The appliances quantity was taken based on appliance to student ratio. For example, if there is two 2hp pump for 800 hundred students then for 400 hundred student it will be one 2hp pump. From this data energy usage and then energy usage after energy conservation measures were calculated and equipment replacement cost and simple pay back was calculated.

Organization

With a modest beginning in 1952 as constituent college of Peshawar University. Peshawar was established in 1980.Located in historic city, Peshawar campus is the reflection of surrounding environment.

University of engineering and technology is a premier institute of higher learning in the province,in the field of engineering sciences. Established as University in 1980, today it boasts twenty-two departments covering an entire spectrum of engineering disciplines from traditional such aa electrical and mechanical to cutting -edges technologies such as electronics, mechatronics, and industrial engineering. To date more than eighteen thousand graduates are serving the needs of Pakistan and many have achieved high position of responsibility and excellence in their chosen field. Besides bachelor's degree courses, there is a robust post-graduate program, where scholars are engaged in rigorous training and research leading to master's and Ph.D. [Source: www.uetpeshawar.edu.pk].

Basic Energy Profiling

Significant energy uses

The following are significant energy uses given in below table:

Table 1: List of significant energy uses in university

S.NO	Significant Energy Uses
1	Lightning
2	Window and split A/C, ceiling, bracket and exhaust fans
3	Gas heaters
4	Motors

Here gas heaters and motors audit are not conducted as they use small amount of energy. There is a single motor per department, so they are not considered. The have little contribution in energy bill.

Energy baseline

The energy baseline was established for one-year data consumption. As seasonal variation effects the energy consumption throughout the year.

Relevant variables effecting significant energy use

The relevant variables effecting significant energy uses are given below:

1.lighting (kWh/lumens).
2.Fans (kWh consumption).
3.Air conditioners (C.O.P).

Energy Source Generation and Distribution

Electrical energy sources and distribution

1) Power Generation

Although electric power is taken from national grid, Diesel generators are installed in university for power supply when there is load shedding.

2) Electrical Transmission (Transformers)

A number of transformers are installed in university which are connected to both Peshawar Electrical Supply Company (PESCO) supply and diesel generator.

3) Electrical Distribution System

Electricity is supplied from main transformers to each department, classes labs, staffrooms, faculty offices etc.

Thermal Energy Sources and Distribution

1) Steam Generation

No steam is generated in UET Peshawar.

2) Steam Distribution

No steam distribution system is present in UET Peshawar.

3) Natural Gas Based

Natural gas is used in winter season in gas heaters for the purpose of heating.

Energy Use Consumption:

Electrical Energy Consumers

1) Lighting System

Current operation and observation:

In UET Peshawar lighting system includes florescent tube lights. Compact florescent lights and LEDS. LEDS are efficient. So, energy savings are calculated by replacing CFL and florescent tube lights with energy efficient LEDS and energy efficient led tube lights.

Table 2: Lighting system calculation for fluorescent tube lights for electrical department

Net Annual Savings (PKR/year)	Rs.507,897
Initial investment (PKR) Pay back	Rs.280,920 7 months

Table 3: Lighting system calculation for compact florescent lamp for electrical department

Net Annual Savings (PKR/year)	Rs.13,926
Initial investment (PKR) Pay back	Rs.4,000 4 months

Table 4: Lighting system calculation for fluorescent tube lights for UET Peshawar (Main campus)

Net Annual Savings (PKR/year)	Rs.2,337,478
Initial investment (PKR) Pay back	Rs.1,303,628 6 months

Table 5: Lighting system calculation for compact florescent lamp for UET Peshawar (main campus)

Net Annual Savings (PKR/year)	Rs.107,580
Initial investment (PKR) Pay back	Rs.86,560 9 months

4. RECOMMENDED ACTIONS

It is recommended that CFL and florescent tube lights is replaced with energy efficient LEDS. It will save energy cost.

The above tables show total 25,674 kWh of energy will be saved if the energy efficiency measures are taken.

Table 6: Light replacement table

Old lights	No of lights	Total energy consumption kWh/yr	New replaced lights	Total energy consumption kWh/yr	Energy saving in kWh/yr	Cost savings rupees/yr (pkr)
18W and 36W florescent tubes	3,352	176,557	18w with 8W LED and 36W with18W LED 3352	70,308	106249	2,337,478
24W CFL	93	9780	12W led	4890	4890	107,580

The above table shows number of lights installed, their energy consumption before and after retrofitting. It also shows energy saved in kWh and cost saved in PKR.

Table 7: Current practices in lighting of electrical department

Observations	Current practices	Impact
Lighting system	Compact florescent lights and tube lights installed are old and inefficient.	As their efficiency are low so they consume more energy. Which results in huge energy bills.

Air Conditioners

Observation of 30 window and 30 split air conditioners of electrical department were taken. Their input power and cooling capacities were noted from their name plate and then comparison have been made with energy efficient air conditioners. It has been observed that the air conditioners were mostly of window type and split type, but they were not energy efficient, considerable number of window A/C were installed which were not efficient and are consuming more energy as compared to modern energy efficient dc inverter air conditioners.

Table 8: Calculation of air conditioners

	split type				window type									
location detail	no of units	tonage	wattage	total wattage	no of units	tonnage	wattage	total wattage	t+window	hrs/day	day/mont	month/ye	hours/yea	kwh/year
P.A to V.C Office	1	2	2700	2700	0	0	0	0	2700	8	22	5	880	2376
Committee Room	0	0	0	0	2	1.5	2570	5140	5140	8	22	5	880	4523.2
Dean Office	1	2	2700	2700	0	0	0	0	2700	8	22	5	880	2376
Staff Room	0	0	0	0	1	1.5	2570	2570	2570	8	22	5	880	2261.6
Conference Hall	4	2	2700	10800	0	0	0	0	10800	8	22	5	880	9504
Office 1	0	0	0	0	1	1.5	2570	2570	2570	8	22	5	880	2261.6
Vedio Conference Room	3	2	2700	8100	0	0	0	0	8100	8	22	5	880	7128
Computer Lab	4	2	2700	10800	0	0	0	0	10800	8	22	5	880	9504
Secrecy Section	1	2	2700	2700	0	0	0	0	2700	8	22	5	880	2376
Exam Section	1	2	2700	2700	2	1.5	2570	2570	5270	8	22	5	880	4637.6
Controller Office	1	2	2700	2700	0	0	0	0	2700	8	22	5	880	2376
Classroom 2	0	0	0	0	2	1.5	2570	5140	5140	8	22	5	880	4523.2
CSNR	1	2	2700	2700	2	1.5	2570	5140	7840	8	22	5	880	6899.2
E 201	0	0	0	0	2	1.5	2570	5140	5140	8	22	5	880	4523.2
E 202	0	0	0	0	2	1.5	2570	5140	5140	8	22	5	880	4523.2
E 202	0	0	0	0	2	1.5	2570	5140	5140	8	22	5	880	4523.2
E 203	0	0	0	0	2	1.5	2570	5140	5140	8	22	5	880	4523.2
E 104	1	2	2700	2700	0	0	0	0	2700	8	22	5	880	2376
I.S.P room	3	2	2700	8100	0	0	0	0	8100	8	22	5	880	7128
E 205	0	0	0	0	2	1.5	2570	5140	5140	8	22	5	880	4523.2
E 206	0	0	0	0	3	1.5	2570	7710	7710	8	22	5	880	6784.8
E 207	0	0	0	0	3	1.5	2570	7710	7710	8	22	5	880	6784.8
ELECTRICAL LIBRARY	0	0	0	0	2	1.5	2570	5140	5140	8	22	5	880	4523.2
E Library	0	0	0	0	2	1.5	2570	5140	5140	8	22	5	880	4523.2
Convocation hall	8	2	2700	21600	0	0	0	0	21600	8	22	5	880	4752
R 208	1	2	2700	2700	0	0	0	0	2700	8	22	5	880	2376
total	30			81,000	30			74,530	155,530					122,610
total kwh/year=														122,610

The above table shows the calculation of air conditioners on excel sheet in electrical department. It shows location, running hours, tonnage and type of air conditioner installed. It also shows the total kWh used by the existing air conditioners per year.

Recommendations Actions

1) Inverter A/C should be purchased while purchasing new A/C.
2) Window A/C should be replaced with inverter split A/C.
3) Windows should be properly shaded.
4) Thermostat should be set above 24 centigrade.

Comparison Between Old Split A/C and New Inverter A/C

The comparison between old split and new inverter A/Cis shown below in table

Table 9: Comparison between old split Unit vs inverter A/C Unit

S.No	Parameters	Old split A/C	Inverter A/C
1	Capacity (ton)	2	2
2	Average power consumption (kW)	2.7	1.5
3	Power savings(kW)	1.2	
4	Summer season operating hour	880	
5	Energy savings per season kWh	1,056	
6	Energy bill savings in PKR in summer season by 2-ton A/C	24,288	

Comparison Between Old Window and New Inverter A/C

The comparison between old window and new inverter is shown below.

Table 10: Comparison between old window and new inverter A/C

S.No	Parameters	Old window A/C	Inverter A/C
1	Capacity (ton)	1.5	1.5
2	Average power consumption (kW)	2.5	1.3
3	Power savings(kW)	1.27	
4	Energy savings per season(kWh)	1,168	
5	Energy bill savings in PKR in summer season by 1.5-ton A/C	25,704	

5. ECONOMIC CALCULATIONS

Calculation For Inverter A/C

The economic analysis of installing inverter A/C is shown in table.

Table 11: Economic calculation for inverter A/C

S.No	Parameters	Details
1	Energy savings in PKR in summer season by 1.5-ton A/C	Rs 25,704
2	Price of new 1.5-ton inverter A/C	Rs 83,000
3	Payback	3.2 years
4	Energy savings in PKR in summer season by 2-ton A/C	Rs 24,288
5	Price of new 2-ton inverter A/C	Rs 112,000
6	Payback	4.6 years

Electrical Ceiling Fan Calculations

Table 12: Electrical ceiling fan calculations for electrical department

Net Annual Savings (PKR/year).	Rs.68,310
Initial investment (PKR) Pay back	Rs.518,225 7.5 years

Table 13: Electrical ceiling fan calculations for UET Peshawar

Net Annual Savings (PKR/year).	Rs.352,880
Initial investment (PKR) Pay back	Rs.2,689,315 7.6 years

Electrical Exhaust Fan Calculations

Table 14: Electrical exhaust fan calculations for Electrical Department

Net Annual Savings (PKR/year).	Rs.3,718
Initial investment (PKR) Pay back	Rs.21,200 5.7 years

Table 15: Electrical exhaust fan calculations for UET Peshawar

Net Annual Savings (PKR/year).	Rs.19,976
Initial investment (PKR) Pay back	Rs.113,950 5.7 years

Electrical bracket fan calculation

Table 16: Electrical bracket fan calculation for electrical department

Net Annual Savings (PKR/year)	Rs.34,166
Initial investment (PKR) Pay back	Rs.306,000 8.7 years

Table 17: Electrical bracket fan calculation for UET Peshawar

Net Annual Savings (PKR/year).	Rs171,790
Initial investment (PKR) Pay back	Rs.1,479,000 8.7 years

Table 18: *Calculation of fans for electrical department*

	Ceiling fan			Exahust fan			bracket fan												
										hrs/day	days/mon	month/ye	hrs/year	replacing 100w with 50w celing fan	replacing exahust fan with 30 w	replacing 65w bracket fan with 50w fan	old total kw-hr	new total kw-hr	kw-hr saved
	no	wt/fan	total watts	no	w/fan	total watts	no	wt/b fan	total watts										
P.A to V.C Office	0	0	0	1	50	50	0	0	0	8	22	6	1056	0	30	0	52.8	31.68	21.12
Bath 1	0	0	0	1	50	50	0	0	0	8	22	6	1056	0	30	0	52.8	31.68	21.12
Committee Room	0	0	0	0	0	0	3	65	195	8	22	6	1056	0		50	205.92	158.4	47.52
Bath 2	0	0	0	1	50	50	0	0	0	8	22	6	1056	0	30	0	52.8	31.68	21.12
Dean Office	1	80	80	0	0	0	1	65	65	8	22	6	1056	50		50	153.12	105.6	47.52
Bath 3	0	0	0	1	50	50	0	0	0	8	22	6	1056	0	30	0	52.8	31.68	21.12
E 101	6	80	480	0	0	0	0	0	0	8	22	6	1056	50	0	0	506.88	316.8	190.08
Bath 4	0	0	0	1	50	50	0	0	0	8	22	6	1056	0	30	0	52.8	31.68	21.12
Staff Room	0	0	0	0	0	0	6	65	390	8	22	6	1056	0	0	50	411.84	316.8	95.04
Conference Hall	1	80	80	0	0	0	6	65	390	8	22	6	1056	50	0	50	496.32	369.6	126.72
Electronics Lab	7	80	560	0	0	0	2	65	130	8	22	6	1056	50	0	50	728.64	475.2	253.44
Vedio Conference Ro	0	0	0	0	0	0	1	65	65	8	22	6	1056	0	0	50	68.64	52.8	15.84
Electrical Machine La	0	0	0	0	0	0	9	65	585	8	22	6	1056	0	0	50	617.76	475.2	142.56
Computer Lab	0	0	0	0	0	0	7	65	455	8	22	6	1056	0	0	50	480.48	369.6	110.88
Bath 5	0	0	0	1	50	50	0	0	0	8	22	6	1056	0	30	0	52.8	31.68	21.12
Secrecy Section	1	80	80	0	0	0	0	0	0	8	22	6	1056	50	0	0	84.48	52.8	31.68
Secrecy Section 2	1	80	80	0	0	0	0	0	0	8	22	6	1056	50	0	0	84.48	52.8	31.68
Exam Section	5	80	400	0	0	0	0	0	0	8	22	6	1056	50	0	0	422.4	264	158.4
Controller Office	1	80	80	0	0	0	2	65	130	8	22	6	1056	50	0	50	221.76	158.4	63.36
Bath 6	0	0	0	1	50	50	0	0	0	8	22	6	1056	0	30	0	52.8	31.68	21.12
Classroom 2	10	80	800	0	0	0	9	65	585	8	22	6	1056	50	0	50	1462.56	1003.2	459.36
Cisnr Lab	0	0	0	0	0	0	6	65	390	8	22	6	1056	0	0	50	411.84	316.8	95.04
E 201	10	80	800	0	0	0	9	65	585	8	22	6	1056	50	0	50	1462.56	1003.2	459.36
E 202	4	80	320	0	0	0	3	65	195	8	22	6	1056	50	0	50	543.84	369.6	174.24
E 202	4	80	320	0	0	0	1	65	65	8	22	6	1056	50	0	50	406.56	264	142.56
E 203	6	80	480	1	50	50	5	65	325	8	22	6	1056	50	30	50	902.88	612.48	290.4
I.S.P room	0	0	0	0	0	0	4	65	260	8	22	6	1056	0	0	50	274.56	211.2	63.36
E 205	6	80	480	0	0	0	7	65	455	8	22	6	1056	50	0	50	987.36	686.4	300.96
E 206	6	80	480	0	0	0	6	65	390	8	22	6	1056	50	0	50	918.72	633.6	285.12
E 207	4	80	320	0	0	0	1	65	65	8	22	6	1056	50	0	50	406.56	264	142.56
R 208	4	80	320	0	0	0	0	0	0	8	22	6	1056	50	0	0	337.92	211.2	126.72
Basic ELECTRICAL Lab	6	80	480	0	0	0	0	0	0	8	22	6	1056	50	0	0	506.88	316.8	190.08
Convocation hall	15	80	1200	0	0	0	8	65	520	8	22	6	1056	0	0	50	1816.32	422.4	1393.92
E 104	0	0	0	0	0	0	2	65	130	8	22	6	1056	50	0	50	137.28	105.6	31.68
total	98			8			98												5,618
				total kw-hr saved=5,618 kw-hr															

The above table is excel sheet of calculations of bracket, exhaust and ceiling fans as well as their location. It also shows their energy consumption before and after energy conservation measures. Total 5,617 kWh of energy will be saved if the recommended energy conservation measure is taken.

Table 19: Electrical fans replacement table

Old fans	No of fans	Total energy consumption kWh/yr.	New replaced fan	Total energy consumption	Energy savings in kWh/yr.	Cost savings rupees/year
Ceiling fans 80 W	493	42,071	Ceiling fans 50 W	26,030	16,040	52,880
Bracket fans 65 W	493	33,839	Bracket fans 50 W	26,030	7,809	171,798
Exhaust fans 50 W	43	2,270	Exhaust fans 30 W	1,362	908	19,976

The above table shows number of fans, their replacement cost, total energy consumption before and after ECMs. It also show the energy saved in kWh and cost saved in PKR.

6. RESULTS (Recommendation with Cost Benefit Analysis)

Short Term /Low-Cost Energy Measures

Lighting System

Compact florescent lamps and compact florescence tube light must be replaced with energy efficient LED.

Lighting Calculation for Florescent Tube Lights

There is total 858 florescent tube lights in electrical department of UET Peshawar and total 3,352 florescent tube lights in UET Peshawar main campus, retrofitting these lights can save 106,249 kWh of energy per year. Which save enough amount of money by reducing energy bills. The good thing about this retrofitting is that it's payback period is 7 months which is less than year. It means it can recover its initial cost in 7 months. Therefore, it is highly recommended to retrofit theses lights.

Net Annual Savings (PKR/year).	Rs.2,337,488
Initial investment (PKR) Pay back	Rs.1,303,628 6 months

Lighting Calculation for Compact Florescent Lamp

There are 25, 24W compact florescent lights in electrical department and 193 lights is UET Peshawar main campus. They are old their energy consumption is high. By retrofitting these lights with 12 W energy efficient led we will save 11,486 kWh per year which will reduce enough amount of energy bill each year. The saving potential in compact florescent light is high as its payback period is 4 months. Therefore, it is highly recommended to retrofit these lights.

Net Annual Savings (PKR/year)	Rs.107,580
Initial investment (PKR) Pay back	Rs.86,560 9 months

Reduce Air Infiltration:

Close all the open areas through which air comes inside the rooms. Close holes with sponges. Fill gaps in doors and windows with sponges.

Medium Term Energy Measure

Replacement of Exhaust Fans

Exhaust fans must be replaced with energy efficient fans, there are 43, 50W exhaust fans. They must be replaced with energy star fans. Which consume less energy. By retrofitting these fans 908 kWh of energy must be saved.

Net Annual Savings (PKR/year)	Rs.19,976
Initial investment (PKR) Pay back	Rs.113,950 5.7 years

Installing New Inverter, A/C 1.5 Ton

There are 30 window A/C in electrical department and 330 in the whole UET Peshawar main campus. They are old. They consume high energy. They are inefficient. One window A/C consume 2.75 kW of energy. While new 1.5-ton inverter A/C consume 1300W energy. Which is quite less than window A/C it will save 41,677,724 kWh of energy saving annually. It's payback period is high, so it is not recommended to change it immediately. So, when installing new A/C energy star rated A/C must be installed.

Net Annual Savings (PKR/year).	Rs.9,167,928
Initial investment (PKR) Pay back	Rs.27,027,000 3 years

Long Term Measure

Installing Ceiling Fans

In electrical department there are 98 80W fans while in whole UET Peshawar main campus there 493 ceiling fans. These fans are old. They are inefficient due to which they consume high energy which results in high electricity bills. Now (NEECA) has introduced star labeling. So, these fans must be installed. Three-star fans must be installed which will reduce enough amount of energy. Their payback period is high, so it is not recommended. But installing new fans these measures should be taken.

Net Annual Savings (PKR/year)	Rs.352,880
Initial investment (PKR) Pay back	Rs.2,689,315 7.6 years

Installing Bracket Fans

In electrical department there are 98 65w bracket fans and in whole UET Peshawar main campus there are 493 bracket fans. These fans are old and in efficient so their energy consumption is high-energy star label must be checked while purchasing new fans.

Net Annual Savings (PKR/year)	Rs.171,790
Initial investment (PKR) Pay back	Rs.1,479,000 8.7 years

Installing 2-Ton Inverter A/C

In electrical department there are 30, 2-ton split A/C while in UET Peshawar main campus there 330 split A/C they are better than window A/Cs. But know with introduction of inverter A/Cs. It has reduced energy consumption. Old split A/Cs are of 2,700 wattages. While new inverter A/C are of 1,500W. By replacing these A/C will save 348,480 kWh of energy. There payback period is high, so it is not recommended to change it immediately.

Net Annual Savings (PKR/year).	Rs.7,666,560
Initial investment (PKR) Pay back	Rs.36,960,000 5years

Expected Energy Consumption and Performance

If all these retrofitting is done in UET Peshawar. Energy consumption will be reduced. Total amount of saving is 19,870,359 PKR 907,696-kilowatt hour energy will be saved which can reduce, huge energy bill.

Annexure

Table 20: Replacing 2 ton non inverter split A/C with inverter A/C

Replacing 2 ton non inverter split A/C with inverter A/C
inverter 2-ton A/C average power=1,500w
total power for 30 inverter air conditions=30*1500=45,000w
total power for 30 non inverter air split conditions=30*2,700=81,000 w
total power reduced=81,000-45,000=36,000w
energy saved in kWh=36,000*880=31,680 kWh
energy cost saved per year=506,880 pkr
initial investment=total A/C Units*cost of one 2 ton A/C=30*112,000=3,360,000pkr
spp=5

Table 21: Replacing 1.5-ton window A/C with inverter split A/C

for window A/C average power per 1.5 ton A/C=2,570W FOR 30 the total power=30*2750=82,500W
for inverter A/C average power per 1.5 ton A/C=1315W FOR 30 the total power=30*1315=39,450w
total power reduced=82,500-39,450=43,050w
total energy saved in kWh=43.050 *880=37,884 kWh/yr
energy cost saved=606,144pkr/yr
initial investment=cost of one A/C*30=81,900*30=2,457,000pkr
spp=2,457,000/606,144=3

Table 22: Replacing 80-watt celling fans with 50-watt energy efficient fans

for replacing 80-watt fan with 50-watt kWh saved =old kWh-new kW--hr=98*80*1,056-98*50*1,056=8,279-5,174=3,105 kWh/year
cost saved=Unit price*kWh=3,105*16=49,680 Rs per 6 months
initial investment=total fan*price per fan=98*5,455=518,225 RS

SPP=Initial investment/annual savings=518,225/49,680=7.6				
Replacing 50-watt exhaust fans with 30-watt energy efficient fans				
for replacing 50-watt exhaust fan with 30-watt fan kWh saved =old kWh-new kWh=8*50*1,056-8*30*1056=422-253=169 kWh/year				
cost saved=Unit price*kWh=22*169=3718 Rs per 6 months				
initial investment=total fan*price per fan=8*2650=21,200 RS				
Replacing 65-watt bracket fan with 50-watt energy efficient fan				
for replacing 65-watt bracket fan with 50-watt fan kWh saved=old kWh-new kWh=98*65*1,056-98*50*1,056=6,727-5,175=1,553 kWh/year				
cost saved=Unit price*kWh=16*1553=34,166 Rs per 6 months				
initial investment=306,000pkr				

PROPOSED M.E.P.S

	Bulb	LED tubes	Downlight	Outdoor luminair
Minimum efficiency level	$60 \leq \Phi < 600$: 80 lm/W $600 \leq \Phi < 1200$: 90 lm/W $1200 \leq \Phi \leq 3300$:110 lm/w	2 feet: 106 lm/W or 100 lm/W (directly on mains)4 feet: 114 lm/W	$60 \leq \Phi < 600$: 70 lm/W $600 \leq \Phi < 1200$: 80 lm/W $1200 \leq \Phi \leq 3300$: 90 lm/W	120 lm/W (output efficiencyof the luminaire, not the lamp)

7. CONCLUSION

This research work comprehensively deals with the energy consumption measures, energy efficiency measure and energy conservation opportunity at the University of Engineering and Technology (UET) Peshawar, Pakistan. The study reveals that about 90% of total energy demand is met by electricity which is mostly consumed by lighting systems, air conditioning systems and fans, while the remaining 10% of energy is consumed by the natural gas used for heating. Through the calculations and detail wise energy auditing and some analysis several Energy Conservation Measures (ECMs) were calculated and evaluated based on their technical achievability and economic payback period.

Similarly, the results conclude that the execution of energy efficiency measures particularly the retrofitting of fluorescent lamps with LED bulbs produce the promising potential values for early savings. From the lighting retrofit we can save approximately 106,249 kWh per year, with simple payback of less a year, which make it most feasible efficiency measure. Similarly, replacing old window and split air conditions with new DC inverter based air conditions can reduce the electricity consumption, though these recommendations require higher initial investments and longer payback period.

The results indicate that by the providing the all recommended energy efficiency measures (ECMs) across UET Peshawar can produce annual savings up to 19.87 million PKR and can reduce the energy consumption by 907,696 kWh annually. These recommendations highlight the total investment of 69.66 million PKR can reduce the UET Peshawar running costs and carbon footprint.

Finally, we can conclude that this research study produces some improving energy efficiency in engineering institutions is not only technically visible but also economically beneficial. We implemented some ECMs measures especially in lighting, DC inverter air conditioners and AC DC energy efficient fans will contribute significantly to long term energy conservation, cost savings and the university commitment to sustainable development. Similarly, these initiatives can serve as a model for further academic organization in Pakistan seeking to control their energy performance and promote an energy conservation and sustainability on campus.

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