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Smoothening of Power Consumption in Academic Institutions: The Case Study of Faculty of Medicine, Sana'a University

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Abstract

Energy Consumption Optimization in the Faculty of Medicine, Sana'a University. The interest of this study is to discover the pattern of energy consumption in the Faculty of Medicine at Sana'a University to reduce energy wastage and enhance efficiency. The study zeroes in on key areas that need optimization in terms of energy use: lighting systems, laboratory equipment, and Heating, Ventilation, and Air Conditioning (HVAC) systems. The strategy to be proposed now will minimize the consumption of energy without affecting the functionality of this faculty by closely analyzing the load profiles and energy audits. This will include upgrading to energy-efficient lighting, optimal equipment scheduling, and adopting energy management systems. This can help the Faculty of Medicine reduce costs related to energy use dramatically, making resource usage more effective and contributing to a better future. The results indicated that these measures can result in considerable cuts in power consumption with maximum estimated savings in electricity up to 59.43%, fuel-57.67, and overall cost-54.61%.

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1. INTRODUCTION

The rationalization of energy consumption is not intended to curtail electricity usage but to optimize its utilization. This involves strategic techniques to guide, sustain, and augment energy efficiency for optimal use and uninterrupted supply. Methodologies aimed at minimizing energy Consumption without compromising user needs or productivity [1–3]. In simpler terms, rationalization involves reducing the wattage drawn by devices, thereby diminishing fuel consumption and bolstering the nation's economy. The implementation of energy rationalization is particularly imperative in Yemen, especially in the context of the current energy crisis characterized by frequent power outages. It is crucial to note that rationalization remains essential regardless of the availability of government electricity. Despite advancements in electrical technology, the Faculty of Medicine at Sana'a University grapples with challenges stemming from antiquated equipment and inefficient start-up processes, which contribute to excessive power consumption. This study delves into analyzing load patterns and developing innovative solutions to optimize energy usage.

2. STUDY CASE

The Faculty of Medicine is one of the most pivotal scientific institutions within Sana'a University and plays a vital role in the advancement of scientific research and in providing basic medical services to the community. Being among the largest within athe university, the medical colleges requires huge electrical power to accommodate a large number of sections and their respective loads [4–6]. The Faculty of Medicine was established in the academic year 1983/1984 and started functioning in modest facilities on the old campus. Later, it moved to its present building at the beginning of the academic year 1989/1990. It hosts a diverse set of loads, including but not limited to lighting, laboratory appliances, monitoring systems, firefighting systems, refrigeration and air- conditioning appliances, lifts, and medical appliances. The electric power supply to the college comes from the main grid and a diesel generator. Both sources received their inputs from fossil fuels. However, under the prevailing conditions in the country at present, the 380 KVA diesel generator is the principal source of electricity for the colleges because the main grid is not always available. The erratic availability of fuel further worsens thethis situation of power supply situation for the colleges.

3. AIM OF STUDY

Thise paper has sought to establish that rationing power consumption in medical colleges is highly essential in ensuring the reduction of energy losses and, hence, effective utilization of scarcescares resources. Significantly, probably one of the great potential benefits is realizable in many aspects, putting into practice an effective energy management strategy through the expansion of monitoring systems, development of computer lab facilities, and recommendatissioning of currently dormant laboratories. ThisIt can bring considerable economic returns from the rational fuel consumption of the generator in either full or partial loading. This will improve the performance by prolonging its life span becausesince the generator will not be overloaded and addsing less cost to its maintenance [7, 8].

4. ISSUES OF ELECTRICAL ENERGY SYSTEM

The increased diversity of electrical devices has caused a day-by-day increase in energy consumption, and problems such as overloading, poor maintenance, and poor wiring with incorrect wire sizing aggravate thise higher consumption. Together, theseAll factors together lead to a higher electricity consumption [9].

5. SOLUTION OF ELECTRICAL ENERGY SYSTEM

The Mmany alternative solutions for all different types of load s-lighting, old machines, and inductive loads-to, name a few-all of which consume a lot of energy, have been found. Each type of load uses a different method to addresstackle the problem of energy consumption problem. For some, Rreplacing old devices with new energy-efficient devicesones iwas the most practical solution. In some studies, the use of soft starters, improvements in power factors, utilization of solar energy, and overall energy management and audit programs have resulted in a substantial reduction in energy consumption[10] .

6. LOAD CALCULATIONS OF FACULTY

During this study at the Faculty of Medicine ofat Sana'a University, we paid close attention to the typeskinds of loads used by the faculty. According to what we determinedfigured out, we attemptedtried to provide appropriate different alternatives for each type of load. Each department has anits kind of electrical load, such as lighting systems, laboratory equipment, monitoring systems, firefighting systems, refrigeration and air conditioning systems, elevators, and medical equipment. To determine the actual patterns of energy use, made several site visits were conducted to record the performance of the operating generator at peak demand to very minimal usage. The currentpresent and future current and potential load requirements of the faculty were then calculated. The Ccalculations of load to estimate the total number offor all blocks in the facility. The resultsThese are summarized in Table 1 .

Table 1. Total loads of all blocks

No. of Blocks	Lighting Load (KW)	Other Loads (KW)
1	94.16	82.56
2	33.04	22.533
3	54.88	34.339
4	46	16.227
5	38.96	68.016
Corridors	16.64	18.531
TOTAL	283.68	242.206
Overall total	525.886 KW	

7. RATIONALIZING DESIGN OF FACULTY

To increase the usage of underutilized equipment, we optimized solutions that metreached industrial standards. For instance, we used Dialux software to calculate the numberamount and type of luminaires required to achieve more efficiency from lighting. By implementing these strategies, we managed to achieved the following reduction in energy consumption: Reduced lighting load: reduceding the number of lamps in offices and classrooms by half, in laboratories by 25%, and in corridors by 35.7%.

Eliminated unnecessary lighting: completely away with all external lighting used only to beautify the external view at night.

Maximized natural light: Mmaximized natural lighting for open spaces [11, 12].

The additional measures taken in extra credit toward energy saving are as follows:

Energy-efficient lLighting: Give Ppriority to the use of energy-efficient LED lamps.

Optimized use of lighting: Tturning off lights when not needed and making full use of natural light where possible during the day.

Efficient lighting design: fewer higher-wattage bulbs rather than a large number of low-wattage bulbsones.

Routine Maintenance: Regular cleaning of light fixtures regularly helped prolong lamp life and maintain optimal light output.

The Ooffices and classrooms are the next major energy-consuming section in the colleges, withhaving several devices such as ceiling fans, computers, printers, fax machines, projectors, network equipment, heaters, and refrigerators. In developing an effective energy use plan for this section, we aimed to substitutetargeted substituting old and power-consuming types of equipment with more energy-efficient ones. Among these are:

Replacement of display systems: Replacing computer monitors with energy-efficient LED screens.

Inefficient equipment replacement: Fans, projectors, and refrigerators awere replaced by their new energy-efficient companions.

Optimized Equipment Usage: Ensured heaters were used judiciously and only when necessary. Efficient Usage of Network: Proper network maintenance and utilization practices were ensured.

The laboratory section comes third in ranking, with the highestmost consumption of energy consumption at the college. The sSpecialized equipment in this section includes screens, ovens, water baths, sterilization devices, refrigerators, and measuring devices. Because laboratory equipment is usually more specialized, there are fewer opportunities to save energy. NeverthelessStill, a saving potential exists by replacing (liquid crystal display) (LCD) screens with (light- emitting diode () LED) screens ones and with the upgradinge of water baths, sterilization devices, and refrigerators.

The last major energy consumer within the college is the pumping system, which includes firefighting pumps, water pumps, and ventilation pumps. To further optimize energy consumption in this sector, we propose the following hypothesis:

Installation of energy-efficient drives: Ssoft start devices or Variable Frequency Drives (VFDs) on water pumps tofor regulateing the speed of the motor to optimize the consumption of energy [13, 14].

Optimized pump operation: Planned Sspecific days are planned when the water pumps would operate to reduce energy consumption.

The following broad energy efficiency measures implemented at the Faculty of Medicine, Sana'a University, will effectively reduce energy use, thus saving money and benefiting the environment:. The resultsThese are summarized in Table 2 .

Table 2. calculation before and after Rationalizing

Type of Loads	Total Power (KW)	New Power (KW)	Saving (KW)	Time(H)	Saving (KWH)
Total Lighting	283.68	34.43	249.25	6	1495.5
Class Rooms	175.89	127.186	48.704	6	292.224
Lab Instrument	47.785	38.717	9.068	6	54.408
Pump	18.531	18.5	0.031	3	0.093
Total	525.886 KW	218.833 KW	307.053 KW	1842.225 KWH	

8. COST STUDY

Cost is one of athe major concerns forin every design project. ThisIt wais the most influentialinfluencing factor in terms of feasibility. Finding the most economical alternativeIt is the greatest preoccupation of a project manager to try to find the most economical alternatives. The project that we are going to work on requires the scrutiny of each component involved in it, and which contributes to its cost. The price of any product depends upon the quality, performance, and brand name of the company manufacturing it. We selectedchoose components with a combination of quality and durability.

8.1. Generator diesel fuel consumption

The amount of fuel consumed by a diesel generator consumes depends on its size and on the load the generator is under. A 300 kW generator running at full load consumes about 21.5 gallons of fuel per hour.

Assuming a fuel consumption rate of 21.5 gallons per hour, with fuel densities of 4.5 liters per gallon of fuel, the fuel consumption per day amounts to 580.5 liters. Over a period of 25 years, taking into consideringconsideration that these plants run for 11 months in a year and 26 days in a month, the total consumption amounts to 4,150,575 liters. Total fuel cost over 25 years, Aassuming a price of $1 a liter, would be $4,150,575.

In comparison, a smaller generator of 125 kW has a fuel consumption of approximatelyabout 9.1 gallons per hour at a full load. For the same calculation as mentioned above, the total consumption of fuel in 25 years wais estimated to beat 1,756,755 liters, with an estimated total cost of $1,756,755.

In this way, by the downsizing of the generator, a fuel cost saving of $2,393,820 over 25 years will be gained. However, to be able to support reduced power capacity, energy-saving measures would have to be applied, such as the addition of fans. Assuming the cost of the new fans amounts to $127,099.05, then the net savings would be $2,266,720.95.

9. CONCLUSION

The design of medical faculty rationalization washas been concluded, and the related costs werehave been estimated, including operational costsones relative to diesel fuel sources. This paper presentswill make a comparative analysis, based on those results, of the electrical system beforeprior to and after the implementation of the rationalization measures. The ranking criteria included mainly reliability, load, fuel consumption, and cost. The values forof each criterion are listedwill be given in Table 3. Therefore, the rationalized electric scheme is much better in terms of reliability, cost, and performance in terms offor fuel economy.

Table 3. Final values of main criteria in the comparison

Comparison	Before Rationalizing	After Rationalizing
Reliability	Less Reliable	More Reliable
Loads	3099.723kw/H	1257.48 Kw/H
Fuel	580.5 Liters/Day	245.7 Liters/Day
Cost	4,150,575 $	1,883854.05 $

The major results obtained are given below:

- The overall reduction in power consumption was 59.43%.
- A significant 57.67% cut in fuel consumption.
- A very noticeable reduction of 54.61% in overall costs.

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