ENERGY MANAGEMENT SCHEME FOR A UNIVERSITY CAMPUS
(CASE STUDY OF A.B.U. ZARIA)

BY

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DECLARATION

I declare that the work in this thesis entitled “Energy Management Scheme for a university Campus case study of A.B.U. Zaria, Main Campus has been performed by me in the Department of Building under the supervision of Engr. A.A. Mati and Dr. Kabiru Bala.

The Information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

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CERTIFICATION

This thesis entitled “Energy Management Scheme for a university campus (Case Study of A.B.U. Zaria Main Campus by Suleiman Aliyu Shika meets the regulation governing the award of the degree of Master of Science (Building Services) of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This research work is dedicated to my late uncle Alh. Hassan Mohammed Shika. May Allah (S.W.A.) grant him Janat Fiddaus. Ameen.

ACKNOWLEDGEMENT

Praise be to Allah for giving me the strength and courage to withstand the rigors of this academic work.

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ABSTRACT

This study assessed the problem of Electrical Energy supply within Ahmadu Bello University, Zaria (Main Campus) and suggested ways of solving the problem of inadequacy of power supply. Reduction of peak demand by load shedding method was used which preserves critical loads or avoids total shutdown due to unforeseen loss of power sources and preserving system stability during sudden loss of power. The concept of load management, load curves and energy auditing processes were reviewed. The data for load/energy consumption was obtained from bulk metering unit 11KV substation of the university, the monthly and yearly peak demands were compiled using the formula for peak demand with result giving in MVA (Mega-Volt-Ampere). Graphs of Maximum demand were plotted against time under consideration and interpretation was made based on the graphs, with useful suggestions. Graph was plotted to show scheme of optimization based on load shedding. Bar charts were used in representing the energy management scheme by load shedding which pictorially shows comparison between electrical energy consumption on normal profile and scheme for optimization. It was discovered from the result of annual load curve that, more power is consumed during the heat period than cold period, due to cooling loads.

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LIST OF SYMBOLS AND ABBREVIATIONS

MVA	Mega-Volt-Ampere
KVA	Kilo-Volt-Ampere
KWH	Kilo-Watt-Hour
AM	Morning
PM	Afternoon
MN	Midnight.
N	Noon.
I	Current.
A	Ampere.
V	Voltage.
A.B.U	Ahmadu Bello University.
NEPA	National Electric Power Authority.
S/S	Substation
Sec	Secondary.
Sch	School.
S.Centre	Social Centre.
Gym	Gymnasium.
Gen	Generator
Dem	Demonstration.

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CHAPTER ONE

1.1 INTRODUCTION

The issue of energy management is very pertinent today, considering the energy crisis and global economic recession. Energy Management is being practiced today in several places with noticeable result and has in fact being suggested for developing countries.

Kaochen (1990). Defines Energy Management as; “Engineering, Design, application, utilization and to some extent the operation and maintenance of systems to promote the optimal use of electrical energy”. “Optimal” in this case refers to the design or modification of a system to use minimum overall energy where the potential or real energy savings are justified on an economic or cost-benefit basis.

Optimization also involves factors such as comfort, healthful working conditions, the practical aspects of productivity, the aesthetic acceptability of the space, and public relations.

According to McVeigh (1976), Managing energy is more than the implementation of energy conservation opportunities since energy

management is a continuous process, it is extremely important to monitor energy usage and to use the result to gauged future actions. In some energy applications such as in combustion processes, measurement or control or both at each point of application may be necessary to ensure efficient use of energy. Measuring methods that best describe the process are necessary to control, evaluate and manage efforts to conserve energy. It is also important to budget the anticipated energy usage so that performance can be evaluated and plans can be made.

Energy Management Scheme for A.B.U Zaria will go a long way in suggesting alternative means of utilization of energy in the Institution with possible controls such as;

1. Temporary disconnection (Shedding) of selected loads
2. The redeployment of selected electrical loads to off-peak periods.
3. The use of a computer based resource optimization facility to minimize overall production costs, including those arising from electricity demand charges.

1.2 NEED FOR THE STUDY

The frequent introduction of new tariff structure which always change energy charges, the increasing student population , non setting of goals to reduction in energy use and lack of improvements in less energy consumption equipments are indicator of the need to develop an energy management scheme (based on the energy use) which can be applied conveniently to A.B.U Zaria (Main Campus) in order to effectively control or manage the electric charges which is becoming a burden on the University, and couple with the fact that the present scheme of energy management lacks insight into areas of building skills needed to succeed in fast changing energy field.

There is also the need for efficient energy management in order to:

i. Implement actions for energy conservation

ii. Determined Energy demand of appliance (Lighting, Kitchen equipment, office machines, refrigerators, electronics etc).

1.3 AIM

The aim of the study is to develop Energy Management Scheme for A.B.U Zaria (Main Campus) which will ensure proper energy

utilization and in the long run save cost without trading-off reliability and comfort.

1.4 OBJECTIVES

The objectives of the research are:

i. To carry out energy audit of the system.

ii. To identify components, new concepts and procedures for energy effective systems, which integrate appropriate controls and techniques.

iii. To develop energy conservation scheme for the system.

1.6 SCOPE

The energy scheme takes account of sources for cooking, lighting, heating, Air Conditioning and Refrigeration and Electronics equipments.

Energy consumption for five years period was considered in the study (1999-2003), due to insufficient record in subsequent years.

The study is confined within A.B.U. Zaria. (Main Campus) and include Residential Area, Academic Area, Student Hostel and Services Areas.

CHAPTER TWO
LITERATURE REVIEW

INTRODUCTION TO ENERGY MANAGEMENT

2.1 GENERAL CONCEPT: - According to NES (1990), the phrase energy management means: The judicious and effective of energy to maximize profits (maximize costs) and enhance competitiveness positions. This rather broad definition covers many operations from product and equipment design through product shipment. Waste minimization and disposal and also present many energy management opportunities.

A whole system viewpoint to energy management is required to ensure that many important activities will be examined and optimized. Presently, many businesses and industries are adopting a Total Quality Management (TQM) strategy for improving their operations. Any TQM approach should include an energy management component to reduce energy costs.

The primary objective of energy management is to maximize profits or minimize costs. Some desirable sub-objectives of energy

management programs include

1. Improving energy efficiency and reducing energy use, thereby reducing costs.
2. Cultivating good communications on energy matters.
3. Developing and maintaining effective monitoring, reporting and
4. Finding new and better ways to increase returns from energy investments.
5. Reducing the impacts of curtailment blackout, or any interruption in energy supplies.

2.1.1 ENERGY BASICS FOR ENERGY MANAGERS

According to capehart teal; “An energy Manager must be familiar with energy terminology and units of measure. Different energy types are measured in different units”.

Knowing how to convert from one measurement system to another is essential for making valid comparisons. The energy manager must also be informed about the rational energy picture. The historical use patterns as well as the current trends are important to an understanding of options available to many facilities. EIA (1995).

Knowing the terminology of energy use and the units of measure is essential to developing a strong energy management background. Energy represents the ability to do work, and the standard engineering measure for energy used is the British thermal unit, or Btu. One Btu is the amount of energy needed to raise the temperature of one pound of water, one degree Fahrenheit. In more concrete terms, one Btu is the energy released by burning one kitchen match head.

According to U.S Energy Information Agency (EIA.1995). "The energy content of most common fuels is well known, and can be found in many reference handbooks. For example a gallon of gasoline contains about 125,000 Btu and a barrel of oil contains about 5,100,000 Btu".

Electrical energy is also measured by its ability to do work. The traditional unit of measure of electrical energy is the kilowatt – hour, in terms of Btu's, one kilowatt – hour (Kwhr) is equivalent to 3412 Btu. However, when electrical energy is generated from steam turbines with boilers fired by fossils fuels such as coal, oil or gas, the large thermal losses in the process mean that it takes about 10,000 Btu

of primary fuel to produce one Kwhr of electrical energy. Further losses occur when this electrical energy is then transmitted to its point of ultimate use. Thus, although the electrical energy at its point of end-use always contains 3412 Btu per Kwhr, it takes considerably more than 3412 Btu of fuel to produce a Kwhr of electrical energy (NES 1990).

2.2 ENERGY MANAGEMENT PROCESSES

2.2.1 THE ENERGY AUDIT PROCESS

Once a commercial or industrial facility has designated its energy manager and given that person the support and authority necessary to develop an adequate energy management program, the first step the energy manager should take is to conduct an energy audit. Also called an energy survey, energy analysis, or energy evaluation, the energy audit examines the ways energy is currently used in that facility and identifies some alternatives for reducing energy costs. ASHRAE (1996).

The goals of the audit are: -

- To clearly identify the types and costs of energy use.
- To understand how that energy is being used and

possibly wasted,

- To identify and analyze alternative such as improved operational techniques and/ or new equipment that could substantially reduce energy costs, and
- To perform an economic analysis on these alternatives and determined which ones are cost-effective for the business or industry involved.

Capehart et al. (1994) addresses the three phases of an energy audit: Preparing for the audit visit, performing the facility survey and implementing the audit recommendations. In the first phase, data from the energy bills is analyzed in details to determine what is being used and how the use varies with time. Preliminary information on the facility is compiled, the necessary auditing tools are gathered, and an audit team is assembled.

Phase two starts after a safety briefing when the team performs a walk-through inspection, looking carefully at each of the physical systems within the facility and recording the information for later use. After the plant survey, the audit team must develop an energy balance to account for the energy use in the facility. Once all energy uses have

been identified and quantified, the team can begin analyzing alternatives. The final step of phase two is the audit report which recommends changes in equipment, process or operations to produce energy cost savings.

Phase Three: - The implementation phase – begins when the energy manager and the facility management agree on specific energy savings and initiate some or all of the actions recommended for achieving those goals. Setting up a monitoring system will allow management to assess the degree to which measures have been successful and which have failed. The result of the monitoring should feed back to the beginning of the audit cycle and this potentially initiate more analysis, implementation, and monitoring.

2.2.1.1 PREPARING FOR AN AUDIT

According to ASHRAE (1996) the energy audit process starts with examination of the historical and descriptive energy data for the facility. Specific data that should be gathered in the preliminary phase includes the energy bills for the past twelve months, descriptive information about the facility such as plant layout, and a list of each

piece of equipment that significantly affects the energy consumption. Before the audit begins, the auditor must know what special measurement tools will be needed. A briefing on safety procedures is also a wise precaution.

GATHERING PRELIMINARY DATA ON THE FACILITY

Before performing the facility audit, the auditors should gather information on the historical energy use, and the factors likely to affect the energy use in the facility. Past energy bills, geographic location, weather data, facility layout and construction, operating hours, and equipment lists are all part of the data nee

ANALYSIS OF BILLS

The audit must begin with a detailed analysis of the energy bills for the previous twelve months. This is important for several reasons: the bills show the proportionate use of each different energy source when compared to the total energy bill; an examination of where energy is used can point out previously unknown energy wastes; and the total amount spent on energy puts an obvious upper limit on the amount that can be saved. The data from the energy bills can be conveniently entered onto a form such as shown in fig. 2.1. Note that the most

significant billing factors are shown including peak demand for electricity.

Location/Metre No_____

From _____ to _____
(Mo. /yr) (Mo. /yr)

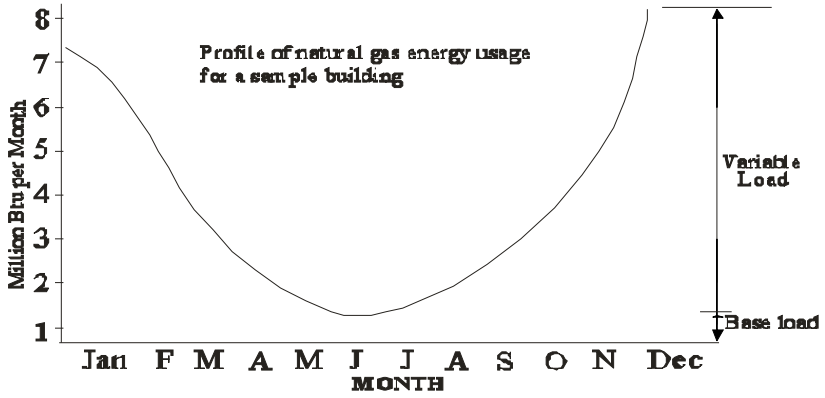
	Electrical use			Gas use		Fuel	
Month	Peak Kw	Usage: Kwh	Cost	M^3	Cost	Gallons	Cost
_____	_____	_____	____	___	____	_____	____
_____	_____	_____	____	___	____	_____	____
_____	_____	_____	____	___	____	_____	____
_____	_____	_____	____	___	____	_____	____
_____	_____	_____	____	___	____	_____	____

Fig. 2.1 Summary form for energy use.
(Source: US Department of Energy Conservation, Institutions for Energy Auditors, DOE/CS-0041/12 and 0041/13, Sept. 1978)

Another way to present data is in graph form. A simple of the type of graph that should be made for each type of energy is shown in figure 2-3. Each area of the country and each different industry type has a unique pattern of energy consumption, and presenting the data as shown in figure 2-3 help in defining and analyzing these patterns. In the facility from which this example came, natural gas is used in the

winter for space heating, so the January peak is not surprising. For electrical consumption, if a peak demand charge is based on the annual peak, the energy auditor must know the time and size of this peak in order to address measures to reduce it.

A complete analysis of the energy bills for a facility requires a detailed knowledge of the rate structure in effect for the facility. To accurately determine the costs of operating individual pieces of requirement, the energy bills must be broken down into their components, such as demand charge and energy charges for the electric bill. This break down is also necessary to be able to calculate the savings from Energy Management Opportunities (Emo's) such as high – efficiency lights and high – efficiency motors, and off peak electrical use by rescheduling some operations.



Graph of energy consumption over time (Courtesy of U.S Dept. of Energy conservation, Institutions for energy Auditors, DOE/CS 0041/12 and 0041/13/Sept. 1978.

2.2.1.2 **THE FACILITY INSPECTION**

Once all the basic data been collected and analyze d, the audit examines facilities for their operational pattern and equipment usage, and should collect detailed data on the facility itself as well as all energy using equipment. This facility inspection should systematically examine the nine major systems within a facility using portable instrumentation and common sense guided by an anticipation of what can go wrong. These systems are the building envelop; the boiler and steam distribution system; the heating, ventilating, and air conditioning system; the electrical supply system, the lighting system; include all light, windows and adjacent surfaces; the hot water

distribution system; the comprises air distribution system; the motors; and the manufacturing system. Together, these systems account for all the energy used in any facility; examining all of them is a necessary step towards understanding and managing energy utilization within the facility.

The facility inspection can often provide valuable information on ways to reduce energy use at no cost or at a low cost. Actually, several inspections should be made at different times and no different days to discover if light or other equipment is left on unnecessarily, or to target process waste that should be eliminated or minimized. These inspections can also help identify maintenance tasks that could reduce energy use. Broken windows should be fixed, holes and cracks should be filled, light should be cleaned, and HVAC filters should be cleaned or replaced.

The facility inspection is an important part of the overall audit process. Data gathered together with an extensive analysis of this data will result in an audit report that includes a complete description of the time-varying energy consumption patterns of the facility, a list of

each piece of equipment that affects the energy consumption together with an assessment of its condition, a chronology of normal operating maintenance practices, and a list of recommended energy management ideas for possible implementation.

THEORY OF LOAD MANAGEMENT

2.3.1 LOAD MANAGEMENT

According to Turner and Wayne, (1980) “Energy management is the process of scheduling loads usage so as to reduce electric energy consumption during peak load period”.

This process suggests an increase in off- peak energy usage and its main objective is to maintain as nearly as possible a constant level of load, thereby allowing the system load factor to approach unity.

2:3.1 TYPE OF LOAD MANAGEMENT

Load management can be divided into two major categories:

(1) Supply load management

(2) Consumer (End-User) load management. (Vogt. & David 1979)

2:3.2 SUPPLY LOAD MANAGEMENT

The type of load management is applied to the electric utility responsible for the generation, transmission and distribution of electric energy. The economic of scale in generation and reasonable fuel and maintenance cost allowed the electric utilities to provide a reliable service at low cost in the past, but now with the global economic and in developing countries more especially the high inflation trend, high cost of maintenance and replacement of system, and increase fuel and Labour cost, the per unit cost has been forced upward. This has made some electric utilities to look at load management as an economic means of improving the efficiency of the electric energy system.

2.4 THEORY OF LOAD CURVE AND LOAD DURATION

2.4.1 LOAD CURVE

Load curve shows graphically the variation of the power consumption with respect to time in a sequential order.

There are various types of load curve: which are dependent on the time under consideration. The load curves considered in this work are:

(i) Daily load curve.

(ii) Monthly Load Curve

(iii) Annual Load Curve

While a typical daily curve is illustrated below for discussion, the scope of this work will further discuss the monthly and the annually load curve which shall come under chapter three.

The demand of daily load curve in fig 2.1 below is taken at hourly interval.

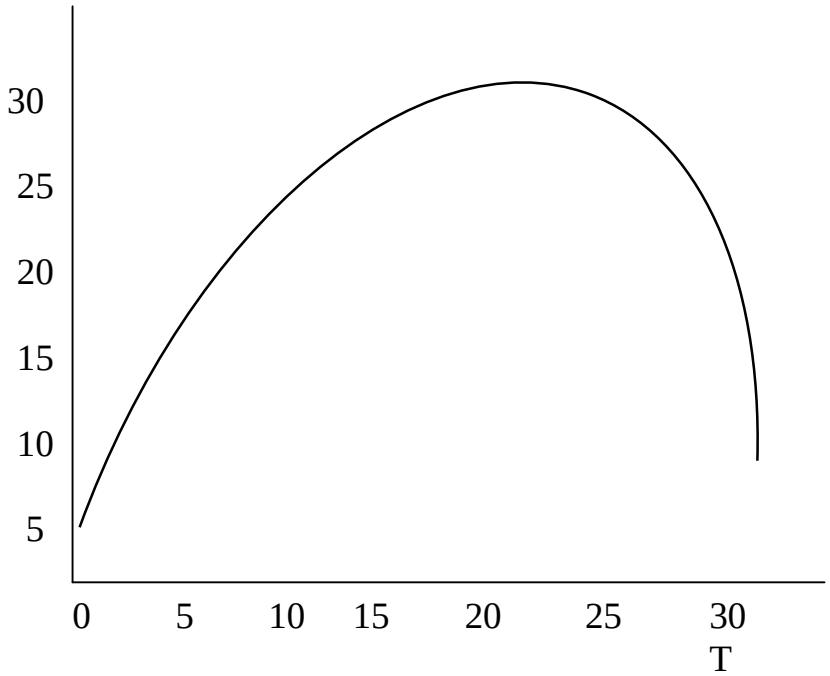


Fig. 2.2 Daily Load Curve
(Source: Guide to energy management)

The following information can be deduced from the load curve,

(a) The area under the curve gives the number of unit of electricity in a given period

(b) The peak of the curve gives the maximum demand on the station during the period under consideration.

(c) Load factor is the ratio of the area under the curve to the total area of the rectangle that contains the curve.

$$\text{i.e. Load factor} = \frac{\text{Average demand}}{\text{Maximum demand}}$$

(d) The average demand on the station is the area under the curve demanded by the total time considered.

i.e. Average demanded = w/t, where

W = Electrical energy (Kwhr generation)

T = period of time for which load curve is considered

2:4.2 LOAD DURATION CURVE

The load duration is the representation of the load versus time with the ordinate arranged in magnitude sequence that is with the greatest load on the left, lesser load toward the right and the least load at the extreme right. The ratio of the area under the curve to the rectangle in which the curve is contained gives the load factor which, however, determined the electrical energy consumption charge. This load factor should be made as high as possible in order to reduce the consumption

charges. The main use of the load duration curve is to give a pictorial representation of the utilization made of the supply system over a given period.

The load curve and the corresponding load duration curve of a particular demand for illustration are shown in fig. 2.2a and fig. 2.2b below respectively.

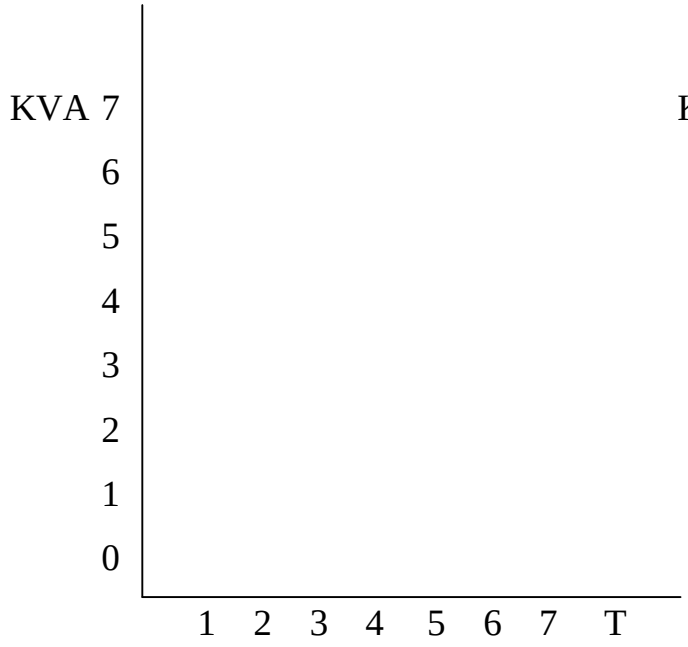


Fig. 2.2a: Load Curve

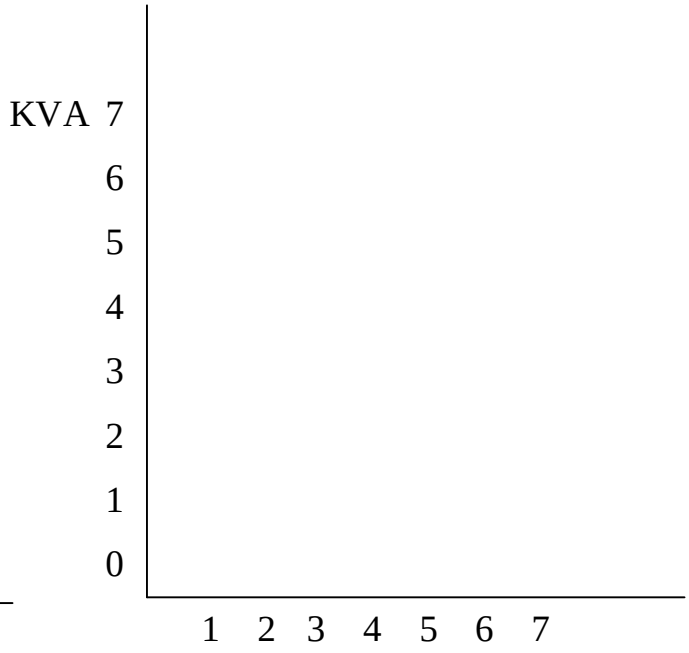


Fig. 2.2b: Load Duration Curve

(Source: Guide to energy Management)

2.4.3 COMPARISON BETWEEN LOAD CURVE AND LOAD DURATION CURVE

While a load curve shows the actual sequence of electrical energy consumption within a given period of time, in contrast, the load

duration curve shows only the total amount of the electricity consumed within the same period. Load curve can take ant graphical shape while, on the other hand, the load duration curves decrease continuously from left to right. The plotting a load curve over a period of time may be very complicated whereas for a load duration curve it will remain a simple graph. In essence, a load curve simplifies the complexity of a load curve when the summation of electrical energy consumed for a particular period is required without the sequence of consumption Vogt et al. (1989).

2.4.3 CHARACTERISTIC OF ELECTRIC ENERGY SYSTEM

The total amount of electrical energy that can be demanded by the consumers at any particular in time cannot be accurately determined due to the nonchalant and dynamic habits of various consumers.

Characteristics of system loads are briefly discussed below:

(i) **LOAD CONNECTED**: This is the total rating in (Kwhr) of all the equipments installed by various consumers.

An electric load is the rate of doing work required of the electrical energy supplied. It is normally measured in Kilowatt or Kilovolt amperes. Electrical loads are rarely constant rather; fluctuate constantly for any appreciable length of time. Load changes from a

particular maximum to a particular minimum value and vice versa. Since 1954, the greatest value of load for a particular period of time is referred to as the peak or maximum demand on the transformer.

(ii) **MAXIMUM DEMAND**: As explained above, it is the peak demand made by the consumer over a given period of time.

(iii) **DEMAND FACTOR:** The ratio of the peak demand to the connected load over a given period is known as demand factor. This can be minimized through proper load management so as to reduce the peak demand over a period of time. Therefore;

$$\text{Demand factor} = \frac{\text{Maximum Demand}}{\text{Connected load}}$$

(iv) **DIVERSITY FACTOR:** A system is said to be diversified when it has a varying load. Therefore, diversity factor can be defined as:

$$\text{Diversity factor} = \frac{\text{Sum of Consumers Maximum demand}}{\text{Maximum demand on the station}}$$

Diversity factor is effective in minimizing the simultaneous maximum demand on the station for the same individual demand. The higher the diversity factor the more reduce is the capital cost for the station and also the overall rate of generating electricity will be reduced" Mustapha (1998)

(v) **PLANT FACTOR:** This is the ratio of the average demand made over a given period of to the plant's capacity. Its typical value ranges from 0.5-0.7. For a constant average demand, the lower the plant factor the higher the plant capacity.

(vi) **LAOD FACTOR:** This can be defined as the amount of electricity supplied in a given period of time over the product of maximum load in this period, and the length of period here can be hours, days, months or annual. Skrozki (1954)

$$\text{Annual load factor} = \frac{\text{No. of units actually supplied per year}}{\text{Maximum power demand x24x365}}$$

$$\text{Monthly load factor} = \frac{\text{No. of units consumed per month}}{\text{Maximum power demand x24x30}}$$

$$\text{Daily load factor} = \frac{\text{No. of units demand per day}}{\text{Maximum power demand x 24}}$$

Load factor can also be defined as the ratio of the average demand to the maximum demand made for a given period. The typical value of load factor ranges from 0.1-0.7. For a constant average demand in a given period, the higher the factor the lower the maximum demand, therefore, the load factor should be made as high as possible.

Generally,

$$\text{Load Factor} = \frac{\text{Average demand}}{\text{Maximum demand}}$$

$$= \frac{\text{Energy generated in a given period}}{\text{Max. Demand x hours of operation of the period}}$$

During a given period of time, the load on a power system will continue to vary from the time to time, with the maximum demand maintained throughout the period, the relationship between the actual load during the period and the loads is defined by the load factor. As far as the economics of electricity generation and consumption is concerned, it is very important to improve load factor so as to consequently reduce the maximum demand during the peak period.

CHAPTER THREE

METHODOLOGY

3.0 METHOD OF DATA ANALYSIS

i. Energy Auditing was carried out, through Measurement required to assess the energy uses and losses.

ii. Peak Demand was obtained, from peak Demand (MVA)

$$= \sqrt{3} \times \frac{KV \times (I_1 + I_2)}{1000} \ldots\ldots\ldots (1)$$

Where,

I_2 and I_2 are the highest current (in amperes) from PHCN. Incomer 1 and incomer 2 respectively.

KV is the computed peak demand; yearly peak demand is the highest peak demand for the whole twelve months of the year

iii. Graphs were plotted for hourly, monthly and yearly Peak demands.

iv. Bar charts were used in presenting the results of percentage peak demand against period of consumption and scheme for optimisation.

3.1 METHOD OF DATA COLLECTION.

The Ahmadu Bello University (Main Campus) gets supply of electricity through the bulk metering unit. The University is connected

to the National grid which supplies voltage of 11 KV. The Bulk metering Unit takes the responsibility of maintaining, repairing and monitoring the electrical system of the entire University Community.

3.1.1 **THE FEEDERS**

The distribution system may be divided into feeders, distributors and service mains. The scope of this work considers only feeders for analysis. Feeders are the conductors which connect the sub-sections (in some cases the generating station) to the distributors serving a certain allotted area.

There are three feeders for A.B.U power distribution network from which the administrative blocks, the academic environment, the student hostels and the residential quarters get their suppliers through substations all together connected to these feeders. The main feeder is connected to the outer ring mains while Amina and Faculty of Medicine feeders are connected to the internal ring.

3.1.2 THE A.B.U MAIN FEEDER

This feeder feeds the highest number of substations. It has under it 28 substations of different rating and capacities scattered all over the University. The substations with their rating and rate of peak demand loading, under A.B.U main feeder is shown in table 3.1.

3.1.3 THE AMINA FEEDER

This feeder has 6 substation connected to it, the substations are of different rating and capacities which also supply some part of the University community. The substations location, with their rating and rate of demand at peak loading, under Amina feeder is shown in Table

3.1.4 THE FACULTY OF MEDICINE FEEDER

This feeder feeds the least number of substations. It has 3 substations of different rating and capacities. Table 3.3 shows the substations under this feeder with their rating and maximum demand at peak loading.

3.2.0 DATA COLLECTION.

The data collected for this work were obtained as current (A) and voltage (KV) of which sample is shown in table 3.4, from where the

daily, monthly and annual peak demand are obtained. The daily peak demand was computed from the data obtained by using the formula;

$$\text{Peak demand} = \sqrt{\frac{3 \times Kv \times I}{1000}} \quad \ldots\ldots\ldots\ldots 3.1 \text{(source, skrozki)}$$

The highest reading of the NEPA feeder incomer (A) was taken with the corresponding NEPA Bus bar Voltage (KV) and are substituted in equation 3.1 for computation of daily peak demand shown in table 3.5. For monthly peak demand, the maximum of the daily peak demand over the period of the month was taken, while the maximum of the monthly peak demand for the whole year (12 months) was taken for the annual peak demand.

CHAPTER FOUR.

4.0 DATA PRESENTATION AND ANALYSIS.

4.1 DATA PRESENTATION.

Table 4.1 SUBSTATIONS UNDER A.B.U MAIN FEEDER WITH THEIR PEAK DEMAND (KVA)

S/NO	Name of Substation	Rating (KVA)	Peak Demand (KVA)
1.	Generator Station	-	-
2.	Senate Building	800	650.00
3.	Student Centre	200	180.00
4.	Water Works	750	500.00
5.	New Sewage	50	33.20
6.	Dam	100	61.10
7.	Old Sewage	200	165.80
8.	Central store	200	100.00
9.	Vice Chancellor's	315	260.20
10.	ICSA/RAMAT	750	690.00
11.	Area B.Z	315	365.30
12.	Gymnasium	200	59.20
13.	Area G.	50	62.00
14.	Area F1	300	346.00
15.	Area F2	220	206.00
16.	Block of 9 Flats	500	358.00
17.	Area E	315	365.00
18.	Area G1	200	215.00
19.	Area G2	200	232.50
20.	Area C	100	123.50
21.	Bomo Road	200	164.00
22.	Harling Darling	200	242.00
23.	I.A.R	750	550.25
24.	Police Station	200	181.00
25.	Nearls	200	135.60
26.	Agric Sc. Faculty	500	340.00
27.	Agric Engineering	200	189.00
28.	Police Gate	300	250.00

Table 4.2 SUBSTATIONS UNDER AMINA FEEDER WITH PEAK DEMAND (KVA)

S/NO	Name of Substation	Rating (KVA)	Peak Demand (KVA)
1.	Vet of Substation	750	492.00
2.	Engineering	750	680.00
3.	KIL 1	750	868.40
4.	KIL 2	800	530.00
5.	Faculty of Science	750	524.30
6.	Amina	750	852.00

Table 4.3 SUBSTATIONS UNDER MEDICINE FEEDER

S/NO	Name of Substation	Rating (KVA)	Peak Demand (KVA)
1.	Building Press	750	590.00
2.	Human Medicine	500	360.00
3.	Vet. Medicine	1000	990.00

Table 4.4

MAINTAINANCE AND SERVICE DEPARTMENT A.B.U ZARIA.

BULK METERING UNIT: READING FOR LOG SHEET.

NAME OF STATION: 11KU-SUBSTATION ABU ZARIA. DAY: FRIDAY DATE: 1-12-03

TIME		PHCN FEEDER INCOMER NO1	PHCN FEEDER INCOMER NO2	PHCN BUS BAR	AMINA FEEDER	ABU MAIN FEEDER	FAC. OF MED. FEEDER
HOURS		AMPS	AMPS	K.V	AMPS	AMPS	AMPS
00	00						
01	00	01	50	11.0	01	55	01
02	00	01	55	10.5	01	75	01
03	00	02	65	11.0	01	65	01
04	00	02	75	10.2	03	90	01
05	00	04	85	10.4	03	110	03
06	00	04	100	10.5	03	115	03
07	00	04	115	10.5	03	125	03
08	00	01	92	11.0	03	119	01
09	00	01	93	9.7	05	119	01
10	00	01	92	9.4	05	112	01
11	00	01	85	9.4	08	107	01
12	00	01	85	9.4	05	106	01
13.	00	01	81	9.6	05	103	01
14	00	01	71	103	05	92	01
15	00	01	62	9.6	02	83	01
16	00						
17	00						
18	00						
19	00						
20	00						
21	00	02	72	9.7	02	98	02
22	00	02	70	10.3	02	95	02
23	00	03	68	11.1	02	81	03
24	00	03	69	11.2	03	80	03

TABLE 4.5 HOURLY VARIATION OF A.B.U DEMAND (MVA) PEAK RATE

TIME	MVA
01am	0.93
02am	0.95
03am	0.95
04am	1.12
05am	1.22
06am	1.75
07am	1.65
08am	1.75
09am	1.92
10am	1.85
11am	1.91
12 Noon	1.87
01pm	1.80
02pm	1.77
03pm	1.70
04pm	1.58
05pm	1.23
06pm	1.12
07pm	1.58
08pm	1.51
09pm	1.25
10pm	1.38
11pm	1.21
12 mid-night	1.18

TABLE 4.6 MONTHLY VARIATION OF A.B.U PEAK DEMAND (MVA)

Months	1999	2000	2001	2002	2003
Jan	3.27	3.43	3.50	2.51	3.69
Feb.	3.30	3.28	3.46	3.19	3.41
March	3.45	3.39	3.24	2.84	3.22
April	3.50	4.38	4.20	4.53	4.09
May	3.60	3.44	4.42	3.30	4.62
June	3.60	3.26	4.33	2.73	3.07
July	3.34	3.12	3.28	2.48	3.23
Aug.	3.18	2.68	2.48	2.43	3.53
Sep.	3.35	3.10	3.09	2.52	3.47
Oct.	3.34	2.90	3.05	3.21	3.18
Nov.	2.93	2.35	3.65	3.00	3.29
Dec.	3.01	2.86	3.74	3.60	2.04

TABLE 4.7 YEARLY VARIATION OF A.B.U PEAK DEMAND VALUE (MVA)

Year	Peak Demand Value (MVA)
1999	3.60
2000	4.38
2001	4.42
2002	4.53
2003	4.62

4.2 DATA ANALYSIS

4.3 LOAD CURVES AND LOAD DURATION CURVE

The daily load curve is obtained from the plotting of load demand (MVA) against time (24 hours) of which the peak is determined. The load duration curve is also obtained for the same period.

Table (4.5) shows the data while the load curve and load duration curves are respectively shown in fig (4.2a) and (4.2b).

Peak demand (KVA) is also plotted against the time internal (12 months) to determine the annual load curves from which the load duration curves are also generated for the same period. In this case, five years are taken into consideration for analysis. Table (4.6) shows the data while load curves and load duration curves are respectively shown in fig. (4.3a) and (4.3b)

The peak demand of each year is also taken and plotted against the corresponding year for the period under consideration to observe the trend. The load curve of fig (4.4) is obtained from the data of table 4.7.

4.4 DISCUSSION

4.4.1 INTERPRETATION OF THE RESULTS:

4.4.2 DAILY LOAD CURVE:

The daily load curve of fig. 4.2a can be interpreted as follows.

(i) The demand started increasing from 3:am which suddenly jumps between 5am and 6am then decrease a little from 6:am to 7:am.

(ii) It picks up again until it reaches a maximum at 9:am.

(iii) It continuously drops gradually till 6:pm

(iv) From 6pm, the demand rapidly picks up and starts dropping gradually again from 7pm which gallops between 9:pm and 10:pm and then continuously drops until starts picking up from 3:am the following day. The trend can be explained as follows;

(i) This is the time people start waking up in preparation for offices and schools especially Muslim. Between 5:am and 6:am more people must have finished with the use of appliances.

(ii) Between 7:am and 9:am almost everybody is awake for the use of electricity.

(iii) After one or two lecture students start coming back to hostels finally or to go back alter.

(iv) Between 6:pm and 7:pm, most people prepare dinner thereby increasing the load. From 10:pm or even earlier, people start going to bed to wake up again around 3:am the following day.

4.5 ANNAUAL LOAD CURVE

The following trend is observed from the annual load curve in fig. 4.3a:

(i) The demand picks up from March and reaches its maximum between April and May every year.

(ii) It then decrease in August and picks up again in September and then become relatively constant between September and October.

(iii) The demand picks up from October and remain relatively how and constant again between February and March.

This trend can best be explained as follows;

For (i) this period is generally hot and many cooling appliances have to be put in use to reduce the heat.

(ii) Between May and June, rain must have started thereby reducing the heat. Warming appliances replace the cooling ones between August and September when rainfall reaches peak. Between September and October, the rainfall stops, to be replaced with winter.

(iii) The winter, which starts between October and November, consequently invites the use of warming devices to compensate

for the excessive cold. Between February and March, the winter stops.

From the analysis so far, it can be concluded that more power is consumed during the heat period than the cold one. This implies that the University pay more in summer (when everywhere is generally very hot) than any other period.

4.5.1 YEARLY LOAD CURVE

From the curve of fig. 4.4, it is obvious that A.B.U consumes more and more power every year which implies more and more charges being paid by the University. This is due to the up growing number of students every year and the increase of date/unit charge of electricity.

Since the number cannot be reduced unnecessarily, then it becomes necessary to adopt a method of load management to minimize their rate of energy consumption.

4.5.2 DESIGN OF LOAD MANAGEMENT SYSTEM FOR A.B.U

It is evident that the demand of electric energy in A.B.U Zaria presently has reached a point that PHCN is facing a difficult task to

cope up with the University maximum demand. The blame of problem of inadequate supply should not be put on only the PHCN but shared by the society. This is due to the fact that a lot of illegal connections are usually done by the students, increasing the point load and consequently overloading the transformer.

Judging from the nonchalant attitude of some consumers and the Problem of improper implementation of load management schemes by the institution, the system is hardly productive. The effective implementation of load management scheme will require educating the residents on the topic. It is important for the University Management to respond to any concept that will minimize the energy peak demand of the University thereby reducing the charge at peak loading.

4.6 CALCULATION OF % REDUCTION OF A.B.U PEAK DEMAND BY LOAD SHEDDING

Total Peak demand (Tp) of A.B.U = $\sum_{n=1}^{37}$ Spn.

Sp = Peak demand of substation.

n = Number of substations.

Tp = 12.95MVA (From table 3.1, 3.2, 3.3)

Using a scale factor of 0.33;

Tp = 4.27MVA

Using table 4.2b and 4.3b;

Total peak demand = 2.784 + 3.492 = 6.28MVA

Using factor of 0.33 gives 2.07MVA

Since the load is shed at 4 hours interval;

Total peak demand per day = 2.07 x 4/24 = 0.345MVA

% reduction of A.B.U peak demand = $^{0.345}/_{4.27}$ x 100% = 8.1%

USING TABLE (4.4)

Total peak demand reduced = 2.74MVA

Using same factor, 0.33 x 2.74 = 0.904MVA

Total peak demand per day = 0.904 x $^{4}/_{24}$ = 0.151MVA

% reduction of A.B.U peak demand $^{0.151}/_{4.27}$ x 100% = 3.5%

total reduction of A.B.U peak demand = 11.6%

This implies that employing the designed load shedding roaster will invariably reduce the total charge paid by the University on electricity by 11.6%.

Fig. 4.1 Peak Demand obtainable against period consumption for Generators supplying Amina Feeder.

Fig. 4.2 Peak Demand obtainable against period of consumption for generators supplying ICSA/RAMAT and OLD SEWAGE S/S

TABLE 4.8 PROFILE OF SUBSTATIONS AND GENERATORS IN USE.

S/NO	Name of Substations	Generator	Rating
1.	Main Gate	Perkin Pet bow	650 625
2.	Amina	Caterpillar 1&2	250 each
3.	Senate Building	Pet bow	320
4.	Computer centre K.I.L	Caterpillar	500
5.	Faculty of Medicine	Pet bow Pet bow	500 500 (Not Functioning)
6.	Water work	Perkin	500
7.	Boaster Station	Mitsubishi	320
8.	I.A.R	Perkin	800

TABLE 4.8a PEAK DEMAND VALUE FOR AMINA FEEDER

S/N	Substations	Peak demand (KVA)	Areas Supplied	% Peak Demand	Peak Demand Obtainable (KVA)
1.	750 KVA Vet. S/S	492	Fac. of Pharmacy	19	93.48
			Fac. of Vet Medicine	24	118.08
			Suleiman Hall	48	236.16
			Main Gate Street Light	9	44.28
2.	750 KVA Engineering S/S	680	Engineering Workshop	30	204.00
			Elect. Engineering Section	10	68.00
			Mech. & Civil	15	102.00
			Adult Education	4.5	30.60
			I & J Quarters	20	136.00
			Sick-bay	4.5	30.6
			Bulk Metering	10	68.00
			Demonstration Sec. Sch.	6	40.80
3.	750 KVA Amina S/S	852	Main Gate Street Light	5.2	44.30
			Amina Hall	27	230.00
			Akenzua Hall	20	170.00
			Ribadu & Alex Hall	23	195.96
			Assembly Hall	5.8	19.42
			A.I.U Mosque	4	34.08
			Basket Ball Pitch & Social Centre	15	127.80
4.	750 KVA S/S Science Faculty	524.3	Fac. of Science	33.5	175.64
			FASS	33	173.02
			Fac. of Education	33.5	175.64

Time	Area to supply	Peak Demand Obtainable (KVA)	Area to Disconnect
2am – 6am	Street Lights, ABU Mosque, Sick Bay. Fac. Of Pharmacy, Fac. Of Vet Medicine	320.56	Vet. S/S, All Hostels. Assembly Hall, Basket ball Pitch & S. Centre, I & J Quarters, Fac. Of Engineering, Bulk Metering & Dem. Sec Sch., & Fac. Of Science S/S
6am – 10am	Amina Hall Ribadu Hall & Alex Hall Dem. Sec. Sch. Sick Bay	497.40	Vet. S/S, Engineering Faculty, I & J Quarters, Bulk Metering, Fac. of Science S/S, Main gate street lights, Akenzua Hall & Suleiman Hall, Assembly Hall, ABU Mosque, Basketball Pitch & Soc. Centre
10am – 2pm	Fac. of Engineering, Fac. of Pharmacy & Sick Bay	498.08	Fac. of Vet. Medicine, street lights, I&J Quarters, Bulk Metering & Dem. Sec. Sch., Fac. of Science S/S, Hostels, Assembly Hall, ABU Mosque, Basketball Pitch & Soc. Centre.
2pm – 6pm	(Fac. of Science & FASS & Fac. of Science & Fac. of Education or FASS & Fac. of Education alternatively) Fac. of Vet. Medicine and Sick Bay.	498.22	Fac. of Pharmacy, street lights, Hostels, Assembly Hall, ABU Mosque, Basketball Pitch & S. Centre, Bulk Metering & Dem. Sec. Sch.
6pm – 10pm	Suleiman Hall Basketball Pitch & Social Centre Street lights, ABU Mosque, Assembly Hall & Sick Bay	491.74	Engineering S/S except Sick Bay, Fac. of Science S/S other hostels apart from Suleiman Hall, Vet Medicine, and Fac. of Pharmacy.
10pm – 2am	Akenzua Hall, I&J Quarters, Street Lights, Basketball Pitch & Social Centre, Sick Bay	478.10	Vet. S/S Fac. of Engineering, Bulk Metering & Dem. Sec. Sch., ABU Mosque, Assembly Hall, All other hostels apart from Akenzua.

TABLE 4.8b Load Shedding Roaster for 2 x 250VA Generators supplying Amina Feeder in the Absence of PHCN Supply.

TABLE 4.9a: PEAK DEMAND VALUE FOR ICSA/RAMAT AND SEWAGE S/S

S/NO	Substation	Peak Demand (KVA)	Areas of Supplied	% Peak Demand	Peak Demand (KVA)
1.	750KVA ICSA/RAMAT	690	Icsa/Ramat Fac. of Social Science, Staff School Cultural Centre New Building	60 16 6 4 14	414 110.4 41.4 27.6 96.6
2.	200KVA	165.80	Old Sewage	100	165.8

TABLE 4.9b Load Shedding Roaster for the Main Gate Generators supplying with output of 2 x 400 KVA supplying Icsa/Ramat & Old Sewage S/S in the Absence of PHCN Supply.

Time	Area to supply	Peak Demand Obtainable (KVA)	Area to Disconnect
2am – 6am	ICSA/Ramat Hall	414.00	Fac. of Social Science, Staff Sch. Cultural Centre, New Building & Old Sewage.
6am – 10am	ICSA/Ramat Hall, Fac. of Social Sciences, Staff School, New Building	662.40	Cultural Centre, Old Sewage
10am – 2pm	Old Sewage, Cultural Centre, New Building, Fac. of Social Sciences, Staff School	441.80	ICSA/Ramat Halls
2pm – 6pm	ICSA/Ramat Halls Fac. of Social Sciences Staff School	786.80	Staff School Cultural Centre
6pm – 10pm	ICSA/Ramat Halls Fac. of Social Sciences New Building Old Sewage	607.40	Fac. of Social Sciences Staff School New Building
10pm – 2am	ICSA/Ramat Halls Cultural Centre Old Sewage	579.8	Fac. of Social Sciences Staff School, Cultural Centre, New Building.

TABLE 4.9.1a Load Shedding Roaster for A.B.U Residential Areas

Time	Substations to supply	Peak Demand Obtainable (KVA)	Substation to Disconnect	Peak Demand Reduction (KVA)
2am – 6am	Area, III,C,E,F1,F2,G1,G2, Block of 9 Flat, BZ, Bomo road, Harling Darling.	2314	Area BZ, Gymnasium	424.50
6am – 10am	Gymnasium, Area III, C,E,G1,G2, Block of 9 Flat, BZ, Bomo road Harling Darling	21865	Area F1, F2	552.00
10am – 2pm	Gymnasium, Area BZ, F1,F2,G1,G2,C Block of 9 Flat, Bomo road Harling Darling	2311.5	Area III, E	427.00
2pm – 6pm	Gymnasium, Area BZ, III,E,F1,F2,G1, G2, Bomo road Harling Darling	2257	Area C Block of 9 Flats	481.50
6pm – 10pm	Area BZ, C, III, E,F1,F2, Gymnasium Bomo road, Block of 9 Flat, Harling Darling	2291	Area G1, G2	447.50
10pm – 2am	Area BZ, III, C, E, F1, F2, G1, G2, Gymnasium Block of 9 Flats.	2332.3	Bomo Road Harling Darling	406.00

TABLE 4.9.1b Table of value for Amina Feeder Using 70% Output from 2x250 KVA

S/no	Substations	Areas to Supply	Maximum Supply Required (KVA)
1.	Amina S/S	Main Gate Street Light Assembly Hall ABU Mosque Basketball Pitch.	44.30 49.42 34.08 127.80
2.	Engineering S/S 750KVA	Electrical Engineering Mechanical & Civil Sick Bay Demonstration Sec. Sch.	68.00 102.00 30.60 40.80
3.	Vet. S/S 750KVA	Faculty of Pharmacy Faculty of Vet. Med. Main Gate Street Light	93.48 118.08 44.28
4.	Science Faculty S/S 750KVA	Faculty of Science Faculty of Arts Faculty of Education	176.04 143.02 175
6pm – 10pm	ICSA/Ramat Halls Fac. of Social Sciences New Building Old Sewage	607.40	Fac. of Social Sciences Staff School New Building

TABLE 4.9.2a Load Shedding Roaster for 350KVA output from 250KVA Gen. Supplying Amina Feeder

Area to be Supplied	Area to be Isolated	Duration of Isolation	Amount KVA of power Supplied During Isolation
Sick Bay ABU Mosque Street Lights	Vet. S/S Sc. Fac. S/S Eng. & Demon. Sec. Sch. Assembly Hall Basketball Pitch & S. Centre	2am – 6am	108.96
Sick Bay Fac. of Sciences Fac. Of Arts	Vet. S/S Amina S/S Fac. of Eng Demonstration Sec. Sch.	6am – 10am	349.66
Demonstration Sec. Sch.	Amina S/S Fac. Sc. S/S Fac. of Vet. Medicine Main Gate Street Light	10am – 2pm	334.88
Faculty of Education Fac. of Vet. Medicine Sick Bay	Amina S/S Fac. of Engineering Demonstration Sec. School Street Lights Fac. of Pharmacy Faculty of S/S & Arts	2pm – 6pm	324.32
Sick Bay Basketball Pitch & S. Centre Main Gate Street Light Assembly Hall ABU Mosque	Vet. S/S Sc. Fac. S/S Demonstration Sec. Sch. Fac. of Engineering	6pm – 10pm	286.20
Sick Bay Main Gate Street Light Assembly Hall	Vet. S/S Sc. Fac. S/S Demonstration Sec. School Faculty of Engineering ABU Mosque Basketball Pitch & S. Centre	10pm – 2am	123.90

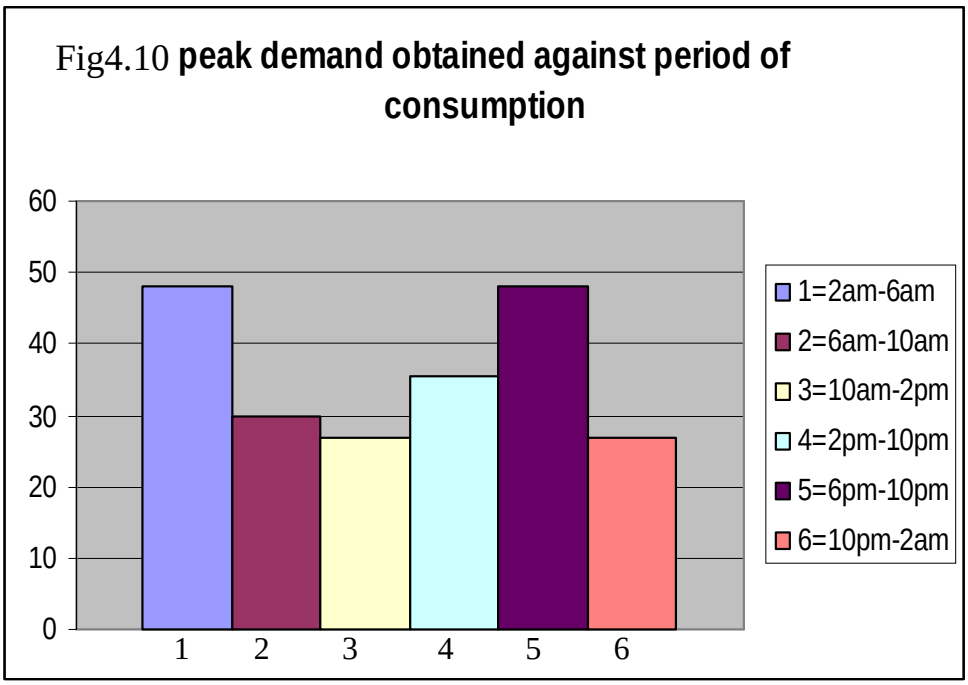
TABLE 4.9.2b Table of value for 70% of 2x400 KVA Out-put from Main Gate Gens.

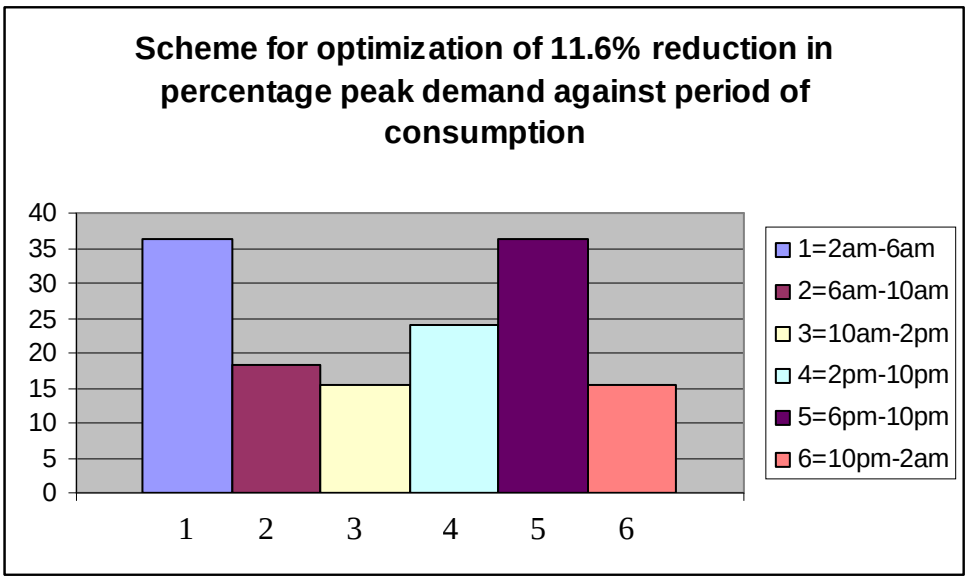
S/no	Substations	Areas to Supply	Maximum Supply Required (KVA)
1.	ICSA/Ramat S/S 750KVA	Fac. of Social Science Staff School Cultural Centre New Building	110.40 42.40 27.60 96.60
2.	Old Sewage S/S 200KVA	Old Sewage	165.80

TABLE 4.9.3a Load Shedding Roaster for 560KVA output from Main Gate Generators.

Area to be Supplied	Area to be Isolated	Duration of Isolation	Amount KVA of power Supplied During Isolation
-	All S/S	2am – 6am	-
Fac. of Social Science New Building Old Sewage	Staff School Cultural Centre	6am – 10am	372.20
Fac. of Sciences Staff School Cultural Centre New Building Old Sewage	-	10am – 2pm	441.20
Fac. of Social Science Cultural Centre New Building Old Sewage New Building	Staff School	2pm – 6pm	399.80
Old Sewage	Fac. of Sciences New Building Cultural Centre Staff School	6pm – 10pm	165.80
	All S/S	10pm – 2am	

4.10 DATA PRESENTATION OF PERCENTAGE PEAK DEMAND AGAINST PERIOD OF CONSUMPTION





CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1.0 CONCLUSION

(1) The study employs the concept of load management, load curves and energy auditing process which suggest the use of high efficiency lights, high efficiency motors and off peak electrical use by rescheduling some operations, using load shedding method which assessed the problem of inadequacy of power supply and suggest ways of solving the problem.

(2) the study established that bulk metering is not the best alternative for metering electricity, rather method of measuring each unit should be employed which will measure energy consumption of each unit/section separately.

(3) It was found out that using control systems, allows unneeded equipment to be tuned off, and allow equipments and systems to be operated in a manner that reduces energy costs.

5.2.0 **RECOMMENDATIONS**

(1) The feeders and the transformers should be given proper maintenance and regular routine inspection.

(2) Implementation of Energy Management System should be highly considered by the University Administration and Bulk metering unit.

(3) Consumers should be educated on load management system to increase their understanding.

(4) The Authority should check the students against illegal connection and tempering with the distribution network.

(5) The University power distribution network should be redesigned in such a way that each feeder is assigned to feed a particular type of load i.e. one for Academic, one for Administrative Block, and the remaining on for Residential/Hostels.

5.3.0 **LIMITATIONS**

(1) The distance between the substations hinders the transferring of load from one transformer to another

(2) The study takes account of only one source of energy

consumption (i.e. electrical energy). Other energy consumptions such as fuel were hindered with lack of full information and the fact that A.B.U lacks utility vehicles.

(3) The time frame of the work could not allow for more data to be obtained from other source such as that of fuel consumption.

5.4 RECOMMENDATION FOR FURTHER WORK

As a way of improving upon this work, possibilities of harnessing energy potentials from other source such as solar, wind, Biomass etc. to generate energy should be investigate. Restructuring the design of A.B.U power distribution network should be looked into, such that each feeder feeds, Academic, Administrative Blocks and Residential/Hostels respectively.

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