Energy Footprint of Selective Commercial Buildings in Dhaka

A Thesis

Submitted to the EEE Department of BRAC University

by

Tahsin Hassan (11221037)

Supervised by

Dr. Abdul Hasib Chowdhury

Associate Professor, Department of EEE, BUET

In Partial Fulfillment of the Requirements for the

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DECLARATION

This is to declare that this thesis named "Energy Footprint of Selective Commercial Buildings in Dhaka" is submitted by the author listed for the degree of Bachelor of Science in Electrical and Electronics Engineering to the Department of Electrical of Electronics Engineering under the School of Engineering and Computer Science, BRAC University. I, hereby affirm that the research work and result was conducted solely by me. Materials of the study and work found by other researchers have been properly referred and acknowledged. This thesis paper is an extension of the thesis paper titled "Development of An Energy Audit Tool for Commercial Buildings in Bangladesh" which was submitted to BRAC University as of August 2015. As such some contents of this thesis is similar to the stated thesis paper above since the research work and development were performed jointly.

Submission Date: 17th December, 2015

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Tahsin Hassan
Student ID: 11221037

Thesis Supervisor:

_____

Dr. Abdul Hasib Chowdhury
Associate Professor
Department of EEE,
Bangladesh University of Engineering and Technology.

ACKNOWLEDGEMENT

Foremost, I express my sincere gratitude to my supervisor, Dr. Abdul Hasib Chowdhury, Associate Professor, Bangladesh University of Engineering and Technology for encouraging me with his valuable guidance to complete this research. I am grateful to all of my peers and every other individual who has supported and encouraged me throughout my research.

ABSTRACT

The demand for energy has risen astronomically over generations and as of today, efficient use of energy becomes a major concern. The built environment is responsible for 40% of the global energy demand [1]. Changes have been made to make buildings more energy efficient. Understanding the use of energy in buildings requires an insight into the amounts of energy consumed and their ways of consumption. The most feasible technique to obtain such level of understanding would be to perform an Energy Audit.

The objective of this dissertation is to obtain a clear understanding of energy efficiency in buildings and specifically in commercial buildings, to find out the energy loss, provide methods and techniques to compensate the loss and to present an energy audit tool.

The study aims to establish the fact that electrical energy use in commercial buildings in Dhaka are quite inefficient and the consumption of electrical energy can be significantly reduced up to 8%-15% energy reduction in electrical equipment and up to 28%-45% in lighting by replacing them with more efficient components.

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ABBREVIATIONS

ANN	Artificial Neural Network
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BLDC	Brushless Direct Current
BNBC	Bangladesh National Building Code
BTU	British Thermal Unit
CFL	Compact Fluorescent Lamp
CFL	Compact Fluorescent light
CFM	Cubic Feet per Minute
CRT	Cathode Ray Tube
EER	Energy Efficiency Ratio
EPA	Energy Power Agency
EPB	Energy Performance of Buildings
EPBD	Energy Performance of Buildings Directive
ERBM	Energy Rating Mark
ESCO	Energy Services Companies
EU	European Union
FL	Fluorescent Lamps
FL	Fluorescent light
HER	Heat Energy Rating
HFO	Heavy Fuel Oils
HID	High Intensity discharge lamp
HL	Halogen Lamp
HPSL	High Pressure Sodium lamp
HVAC	Heating Ventilation Air Conditioner
kWh	Kilo Watt Hour
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LPSL	Low Pressure Sodium Lamp
LRV	Light Reflection Value
NBN	Bureau voorNormalisatie
SAP	Standard Assessment Procedure
SEER	Seasonal Energy Efficiency Ratio
TCF	Trillion Cubic Feet
VBA	Visual Basic Applications
VBE	Visual Basic Editor

1. INTRODUCTION

Electrical energy plays a crucial role in the economic and infrastructural development of a nation. In today's world, demand for electrical energy is so extensive that it penetrates all economic sectors. As of 2013, the consumption of electrical energy increased by 1.4% than that of 2012 which equates to 4185 tons of oil and 3030 tons of natural gas [1]. It is an obvious indictor to extensive use of fossil fuels to produce our require energy which is non-renewable in nature. Although extensive development resulted in alternatives such as wind, solar, geothermal, tidal, wave and biomass as the sources to produce energy which is renewable but these still remains as unsustainable solution.

In Bangladesh till May 2015, the record annual peak demand of power was 10806 MW [2]. According to Bangladesh Power Development Board, the installed power generation capacity is about 11532 MW, out of which 250 MW is generated by coal-fired power plants, 7278 MW from thermal or gas power plants, 230 MW from hydro power stations and 500 MW are imported as of July 2015 [3]. In spite of this, the daily demand for electricity is not met.

Bangladesh relies heavy upon natural gas for its power generation due to being the seventh-largest producer of natural gas in Asia [4]. According to International energy experts, Bangladesh has the reserve of 15 Tcf of natural gas to meet its need of immediate future and it is expected to last for nearly next two decades and after Bangladesh will have to look for substitutes in terms of non-renewable sources. [5]

Over the last six years, electricity users rose form 47% to 64% and it is believed to be outreached to 90% by 2019 and by 2040, the electricity demand will extend to 63600 MW with an annual increase of 8% [2]. According to a report published in June 2006, agricultural and industrial demand accounted to about 48% while the domestic was about 42.4% and commercial needs resulted for 7.63% with the rest accounted the miscellaneous activities [6].

Thus, improvement in energy efficiency and mode of conservation can pave ways to mitigate energy demand on a cheaper and faster scale. Energy conservation means reduction

in energy usage by less energy service and energy efficient means less energy for a constant output.

1.1 Energy Audit & Energy Footprint Definition

Energy Audit is the process of assessment, survey and analysis of energy flows within a system to conserve energy in a building. The aim is to reduce the amount of energy input into the system without having adverse effects on output [7]. Energy Footprint, on the other hand, is defined as the estimated annual energy usage over the area of the structure. As such, energy footprint produces a numerical value to a structure which results in easier comparison between similar energy using buildings. In Bangladesh, the energy efficiency and conservation rules were passed in 22nd October, 2012 from the Ministry of Power, Energy and Mineral Resources which states that all the commercial buildings must comply the rules and use efficient, and cost-effective life cycle appliances following Bangladesh National Building Code (BNBC) [8].

1.2 Literature Review

Research and development on energy audit have been conducted by electrical engineers and building specialists for quite some time. However, the energy crisis in 1973 accelerated the major progress on the field onwards.

European Union Directive Building Conduct

European Union Directive on Energy Performance on Buildings was proposed (EPBD) on 16th December, 2002 which became the major subject for future studies on energy performance on buildings. EPBD aimed to improve the energy performances of the building by accounting the internal and external factors into considerations. Some of the requirement stated by EPBD was an outline of integrated energy performance of a building along with the minimum use of appliances and minimum requirements of energy performance in major

buildings that are subjected to renovation also provide energy efficiency certificates for the buildings. A noticeable procedure of EPBD was the national energy performance calculation procedure on buildings and is followed by improvement techniques and certification. [10]

The releases of EU directive on performance of buildings lead many countries such as UK, Denmark, Ireland, Netherlands, France, Belgium, and Germany to follow the rules. [11]

Standard Assessment Procedure (SAP) is obligatory for new buildings in UK since 1995 and it is mainly concerned on annual cost of heating, lighting, building envelope insulation, efficiency of heating and domestic hot water system. The fuel prices affect the SAP rating, which ranges from 1-100. SAP does not include location, consumption on domestic appliances and does not suggest for making buildings more energy efficient. [12]

In Ireland during the 1990s, HER (Heat Energy Rating) and ERBM (Energy Rating Mark) 8were introduced and was compulsory for all newly constructed buildings. ERBM provides low energy consumption in the buildings and are widely used by fuel suppliers and house builders. ERBM is based on the CO_2 emission and consumption of energy along with the outputs of HVAC appliances. [13]

The Ministry of Housing and Transport of France setup the Decree 2000-1153 for new non-industrial buildings so that all the new buildings comply with regulations. Two methods are introduced for calculation purpose where method one is a precise process developed for experts and the second one is for common people. [14]

In Belgium regulations such as NBN B62-002 and NBN B62-004 have commenced since 1997 and are obligatory for all buildings in residential areas. They are mainly concerned with the heat transfer coefficient for a building, and the legislation limited to $0.55W/m^2$ degree Celsius [15].

1.3 Thesis Objective

The objective of this paper is to study how energy footprint can be developed to help make buildings more efficient and the precursor to this is to study energy flows in commercial buildings. However, due to numerous limitations of instruments I had to confine my comprehensive study to some major areas which will be discussed in the following chapters.

1.4 Thesis Organization

In the first chapter, I explained the current scenario of overall energy crisis and defined energy audit and energy footprint with recent energy studies. The second chapter of my thesis paper will mainly discuss the significance of energy audit and energy footprint. It will also outline the basic steps to perform an energy audit which is the precursor for energy footprint of a building. Chapter three entirely focuses on my energy audit tool and explains the working principle. The fourth chapter is based on the physical audits performed and eventually calculating energy footprint. The last chapter is the conclusion part where further research topics and developments are stated.

2. SIGNIFICANCE OF ENERGY AUDIT& ENERGY FOOTPRINT

Energy Audit can be an essential tool to save energy bills and to conserve national energy resources of a country. Bangladesh, a country with population over 170 million and greatly depends upon natural resources for power generation; energy audit along with energy footprint can be an effective combination to accomplish a comprehensive energy management program.

2.1 Energy Footprint Basics

Energy Footprint refers to a numerical value which is the estimate annual energy consumption over the area the energy is being consumed.

2.2 Energy Auditing Basics

Energy audits can pave way for faster and cheaper method of energy conservation and help reduce energy cost. Quality of energy audit is largely dependent on the cost of hiring auditors and their experience. Simple energy audit provides building owner with a list of suggestions that can be implemented by maintenance staff. Generally energy services companies (ESCOs), energy consultants and engineering firms offer the services of energy audit. In order to conduct the auditing the whole process is divided into three levels. They are as follows:

Level 1: Site Assessment Audit

Site assessment audit is physical site inspection of the building where the auditor takes the note of key energy consuming systems. The activities include an assessment of electric bill, gathering information on key energy consuming systems and minimal interviews with site

operating personnel. Typically, with level 1 we cannot expect a large change in the energy conservation.

Level 2: Standard Energy Audit

Standard audit include an in-depth analysis of energy cost, energy usage, review and analysis of equipment, systems and building characteristics. Interviews are conducted with facility operating personnel to understand the major energy consuming system as well as variations in daily and annual energy consumption and demand. Utility bills of 12 to 36 months are collected to evaluate the facility demand rate structure and energy usage profile. This level of audit gives a bit more precise energy consumption patterns as more details operation of the buildings provide usage data.

Level 3: Simulation Energy Audit

Level 3 energy audit is simulation based and is estimated using specialist software to process data. It develops a dynamic model of energy usage pattern of both the existing facility and all energy conservation measures are identified. The auditors need to develop computer simulation software that will predict year round energy use for weather and other variables. The actual utility is used as a baseline in comparison to the proposed measures. Finally, a professional energy audit report have to be prepared by the auditors which includes all the data, savings and a list of recommendations to save the energy.

From the above three levels, the auditing phases and activities can be summarized in Table 2.1:

Table 2.1: Audit Phase

Auditing Level	Activities
Level 1:Walk-Through Audit	1.Collect and analyze utility data 2.Minimal interview with site personnel 3.Visually inspect building and key systems
Level 2: Standard Audit	1.Comprehensive interview of building staff

Auditing Level	Activities
	2.Evaluate and compare utility and site data 3.Generate energy and cost savings
Level 3: Detailed Energy Audit	1.Develop simulation tool 2.Prepare a report 3.Energy conservation measures are presented

2.3 Instrumentation

In order to collect the data to identify and analyze the present energy consumption, auditors require specialist instruments to find the approximate saving from the analysis. The common measures required to identity for a commercial building are the following, area of windows and rooms and their air flow with leakage, light intensity and temperature etc.

Commonly used instruments are mentioned below.

Lux Meter

A lux meter is a photocell which measures the output lights and expresses the measured value as lux to find the illumination level of light in a room.

Leak Detectors

Leak detectors are used to find out the leaks between the windows and door panels which are impossible to identify with human eyes.

Infrared Thermometer

This instrument is used to measure the surface temperature of a hot body e.g. walls to find out the heat transfer through the walls. It shows the direct temperature reading of any heat source.

Anemometer

During energy audit of commercial buildings, anemometer is used to find the velocity and pressure of air that passes through the leaks.

2.4 Lighting Audit

Although Bangladesh has one of the lowest per capita energy usage in the world (321 kWh), only 62% of the total population has access to electricity [16]. Lighting consumes a larger portion of the total generated power in the world which is about 25% to 35% [17]. Lighting systems consumes up to 15% and 30% respectively in residential and commercial buildings [18]. Fluorescent Lamps (FLs) and Compact Fluorescent Lamp (CFLs) are higher preferred to Incandescent Lamps because of four times higher efficiency and three times higher lifetime at the same luminous level [19]. Lighting energy usage can be reduced by 75% to 90% compared to the conventional practice [20].

2.5 Electrical Audit

Electrical audit refers to the audit conducted on electrical appliances used by residential, commercial buildings and these include the equipment that we use in our daily life. The purpose is to identify the energy consumption of this equipment to understand how alternatives if necessary can be proposed. The owners get benefit from reduced energy consumption and due to better equipment.

2.6 Envelope Audit

The building envelope defined the structural boundary of the building, some of which are the roof, sub floor, ceiling, windows and exterior walls. The significance of envelope audit is often underestimated due to lack of proper instrumentation. Envelope audit identifies the ways energy is wasted, leaked which are not visible to our human eye. Improvement in better sealant for windows and doors help improve energy conservation.

3. DEVELOPMENT OF AN ENERGY AUDIT TOOL

A complete energy audit is the precursor to calculating energy footprint and to perform an energy audit, the steps mentioned in the previous chapters are to be performed. Developing this tool has made it more convenient to perform the audit.

3.1 Programming Language

The energy audit tool is created using Microsoft Office Software in particular MS Excel. The programming language used in MS Excel is VBA which stands for Visual Basic for Applications.

3.2 Introduction to EnergyWise

The developed energy audit tool is named as "EnergyWise". The tool has three primary sectors which correspond to the three audit subsections discussed in the last chapter. The sections are Lighting Audit, Electrical Equipment Audit and Envelope Audit.

Upon starting the tool, the starting page is the instruction tab which is shown in Figure 3.1.

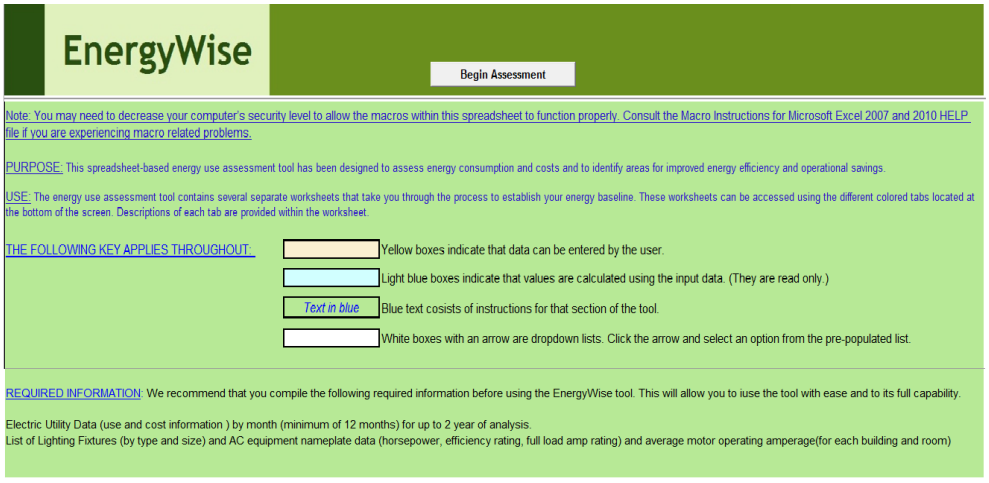


Figure 3.1: Instruction Page

Figure 3.2 shows us the next tab, which is the background information and electricity bill page.

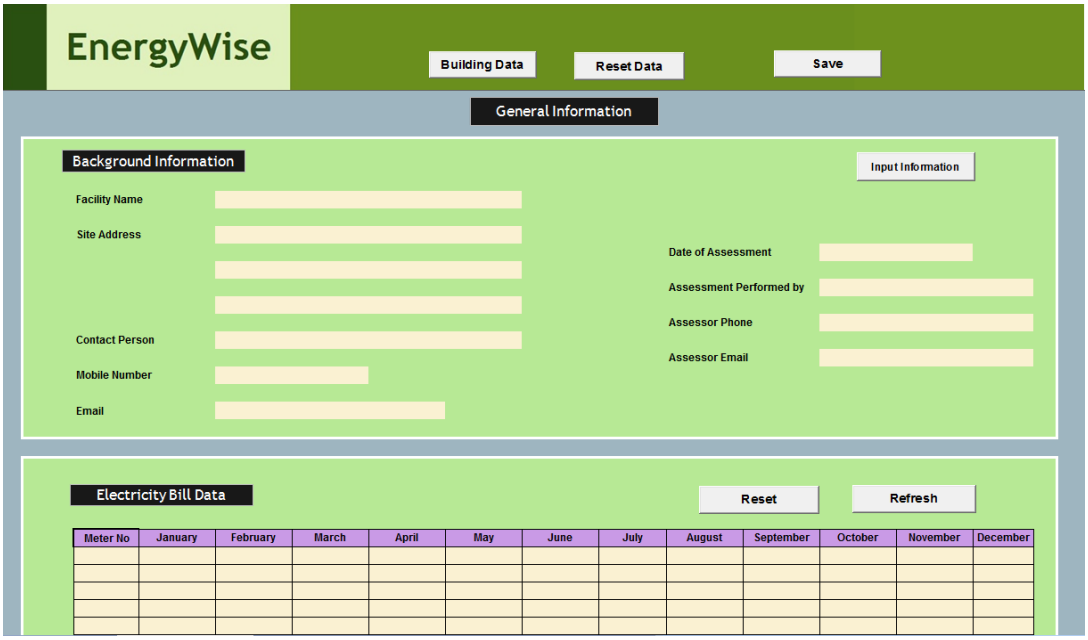


Figure 3.2: Background Information

In this second tab, the general information about site is recorded. The lower half of the tab records the electricity bill data.

4. AUDITING OF SELECTED BUILDINGS

At this point, the field investigations of the selected buildings were made in the months between October – November of 2015. This step is considered as the primary walkthrough of the energy audit where data are being collected for secondary processing. The following buildings are chosen for this analysis.

1. BRAC University Building 4
2. BRAC University Building 1
3. Yeasmin Tower

4.1 BRAC University Building 4 Audit

The building located at Plot 44, Mohakhali C/A Dhaka, was built for office use purposes which now houses the fourth academic building of BRAC University. There are 19 floors in the building except the ground which is used for parking and generator facilities. Each floor has an approximate area of 3600 sq.ft. The working hour of the building is from 8am – 9pm but the occupancy rate is most high during 9am – 5pm.

The building is south facing with windows only on the south and north faces. The east and west sides are blocked by the adjacent buildings.

All floors are air conditioned except ground floor and stairways area. The building has two elevators that run on alternate floors.

Lighting System:

The hall, lobby and public lavatory can be considered as the public zone of the commercial-building. The lighting system of the public zone can be basically divided into twotypes:1) 23W CFL lamps; 2) 36WT8 fluorescent light.

The lighting system used in the classroom, computer lab, faculty area all has T8 fluorescent lamps of 4 in one fixture with reflectors. Spotlights are being used in exhibition hall of Architectural Department.

Air Conditioning:

The classrooms, computer lab and faculty housing areas are mostly air conditioned. Although their no central air conditioning system installed rather the use of split air conditioner meet the cooling needs in the summer days. In my observation, it is necessary to point out their lacking of maintenance which has drastically reduced their cooling capacity. Also, inadequate number of air conditioner may stress the utility bill as they are required operate longer and in inefficient conditions.

Office facilities:

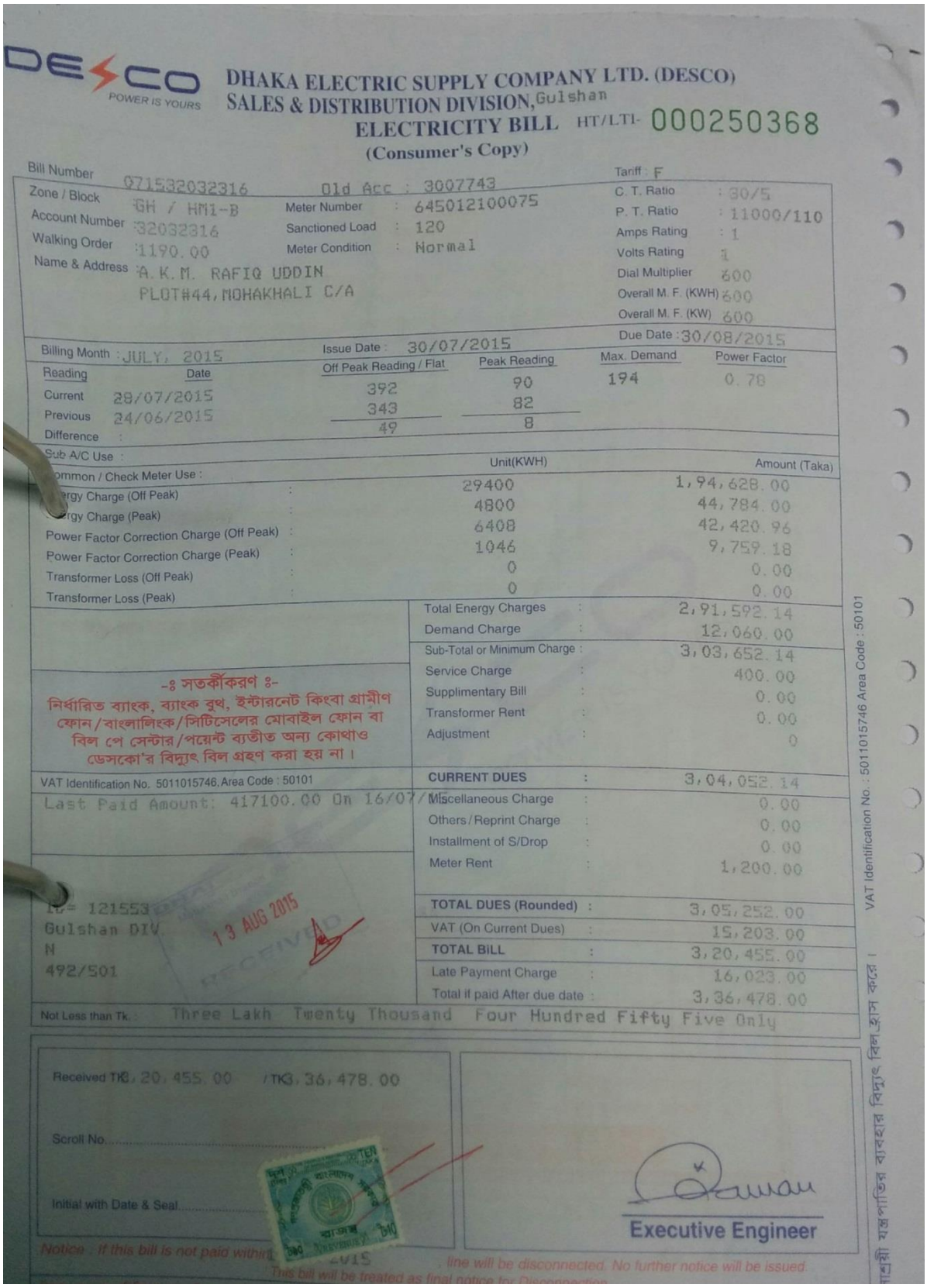
The academic building mostly houses the following departments

1. Department of Architecture
2. School of Law
3. School of Economics and Social Studies

The electrical equipment required by these offices is mostly computer, some projector, a couple of photocopiers.

4.2 Calculations of BRAC University Building 4

From the electricity bill, we have a precise idea about the building's energy consumption. Although we did not get much idea about variation of energy consumption due to seasonal change as we did not get the 12 month electricity bill. We get the electricity bill of July, August and September. According to our assumption, the electricity bill of those months is higher compared to the other month as summer season is consisting of those months. However, data is entered to "EnergyWise" and it generates corresponding chart which will be shown later in this chapter.



DESCO
POWER IS YOURS

DHAKA ELECTRIC SUPPLY COMPANY LTD. (DESCO)
SALES & DISTRIBUTION DIVISION, Gulshan
ELECTRICITY BILL HT/LTI- 000250368
(Consumer's Copy)

Bill Number 071532032316 Old Acc : 3007743 Tariff : F
Zone / Block GH / HM1-B Meter Number : 645012100075 C. T. Ratio : 30/5
Account Number 32032316 Sanctioned Load : 120 P. T. Ratio : 11000/110
Walking Order 1190.00 Meter Condition : Normal Amps Rating : 1
Name & Address A. K. M. RAFIQ UDDIN Volts Rating 1
PLOT#44, MOHAKHALI C/A Dial Multiplier 600
Overall M. F. (KWH) 600
Overall M. F. (KW) 600

Billing Month : JULY, 2015 Issue Date : 30/07/2015 Due Date : 30/08/2015

Reading	Date	Off Peak Reading / Flat	Peak Reading	Max. Demand	Power Factor
Current	28/07/2015	392	90	194	0.78
Previous	24/06/2015	343	82		
Difference		49	8		

	Unit(KWH)	Amount (Taka)
Sub A/C Use :		
Common / Check Meter Use :		
Energy Charge (Off Peak) :	29400	1,94,628.00
Energy Charge (Peak) :	4800	44,784.00
Power Factor Correction Charge (Off Peak) :	6408	42,420.96
Power Factor Correction Charge (Peak) :	1046	9,759.18
Transformer Loss (Off Peak) :	0	0.00
Transformer Loss (Peak) :	0	0.00
Total Energy Charges :		2,91,592.14
Demand Charge :		12,060.00
Sub-Total or Minimum Charge :		3,03,652.14
Service Charge :		400.00
Supplimentary Bill :		0.00
Transformer Rent :		0.00
Adjustment :		0
CURRENT DUES :		3,04,052.14
Miscellaneous Charge :		0.00
Others / Reprint Charge :		0.00
Installment of S/Drop :		0.00
Meter Rent :		1,200.00
TOTAL DUES (Rounded) :		3,05,252.00
VAT (On Current Dues) :		15,203.00
TOTAL BILL :		3,20,455.00
Late Payment Charge :		16,023.00
Total if paid After due date :		3,36,478.00

-ঃ সতর্কীকরণ ঃ-
নির্ধারিত ব্যাংক, ব্যাংক বুথ, ইন্টারনেট কিংবা গ্রামীণ ফোন/বাংলালিংক/সিটিসেলের মোবাইল ফোন বা বিল পে সেন্টার/পয়েন্ট ব্যতীত অন্য কোথাও ডেসকো'র বিদ্যুৎ বিল গ্রহণ করা হয় না।

VAT Identification No. 5011015746, Area Code : 50101

Last Paid Amount: 417100.00 On 16/07/

ID= 121553
Gulshan DIV
N
492/501

13 AUG 2015 RECEIVED

Not Less than Tk. : Three Lakh Twenty Thousand Four Hundred Fifty Five Only

Received TK. 3,20,455.00 / TK. 3,36,478.00

Scroll No.....

Initial with Date & Seal.....

Executive Engineer

Notice : If this bill is not paid within [illegible] 2015 , line will be disconnected. No further notice will be issued.
This bill will be treated as final notice for Disconnection

VAT Identification No. : 5011015746 Area Code : 50101

শ্রেণী যন্ত্রপাতির ব্যবহার বিদ্যুৎ বিল হ্রাস করে।

Figure 4.1: BRAC University Building 4 Electricity Bill of July

The data we have collected from the building, we put them into "EnergyWise" to get calculations and the output of the tool for the building.

Starting the process with lights, table 4.1 shows the concise lighting information of the BRAC University building 4.

Table 4.1: Concise Lighting Audit Calculation of BRAC University Building 4

Lamp Type	Quantity	Lighting Load (kW)	Monthly Energy Consumption (kWh)	Monthly Cost (BDT)
CFL (23W)	178	4.094	818.8	৳7,844
Fluorescent T8 (36W)	1128	40.608	8121.6	৳77,805
LED Spot Lights (50W)	30	1.5	300	৳2,874

From the "EnergyWise" we get monthly lighting cost for CFL equals to BDT 7844, 77805BDT for FL T-8 and 2874BDT for spotlights. The monthly energy consumption of are stated as shown but the operating hours equal to 10 hours per day for 20 days in a month. This approximation is made to make the estimate for realistic. Moreover, the total monthly lighting cost is 88.523BDT. From lighting summary fifth tab of the tool, we get two pie charts, shown in figure 4.5 and 4.6.

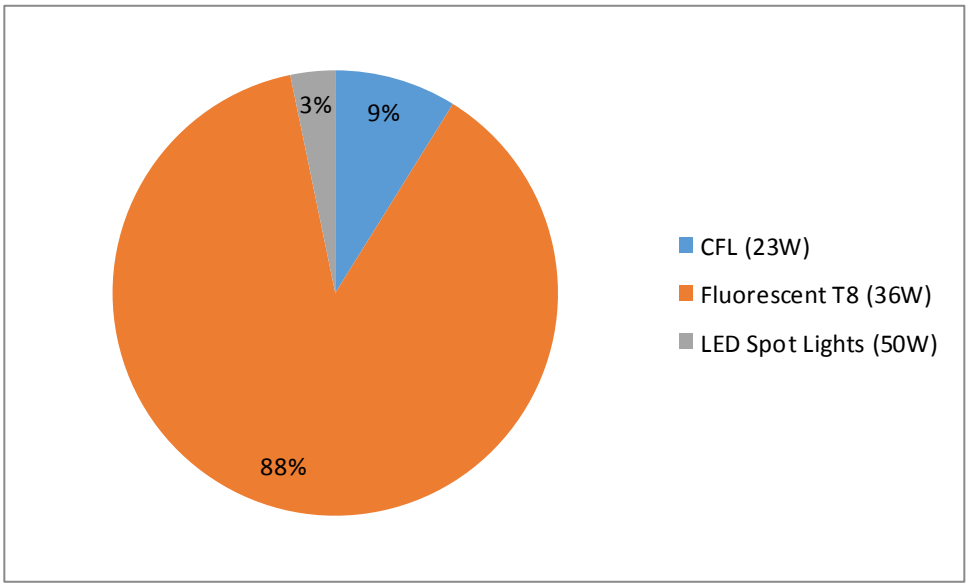


Figure 4.2: Total Lighting Load of BRAC University Building 4

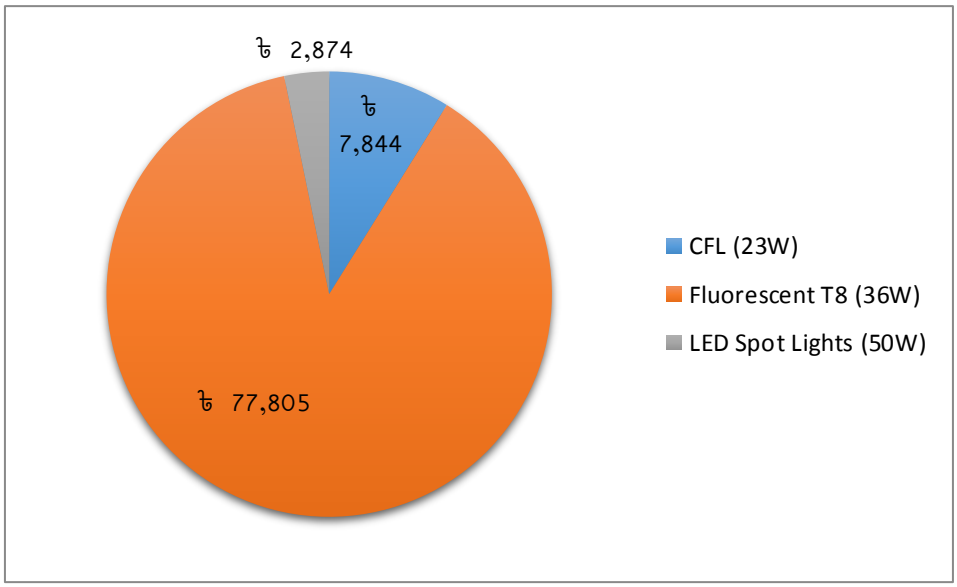


Figure 4.3: Monthly Lighting Cost of BRAC University Building 4

From this figure, we can see FL T-8, CFL and Spotlights are responsible for 88%, 9% and 3% lighting cost respectively.

Next we move to electrical equipment calculations, table 4.2 shows the concise information about electrical equipment.

Table 4.2: BRAC University Building 4 Electrical Equipment Cost in Concise way.

Equipment Type	Quantity	Load (kW)	Monthly Energy Consumption (kWh)	Monthly Cost (BDT)
Air Conditioner	31	124	24800	৳237,584
Desktop Computers	475	166.25	33250	৳318,535
Projectors	15	4.95	990	৳9,484
Ceiling Fans	114	9.12	1824	৳17,474

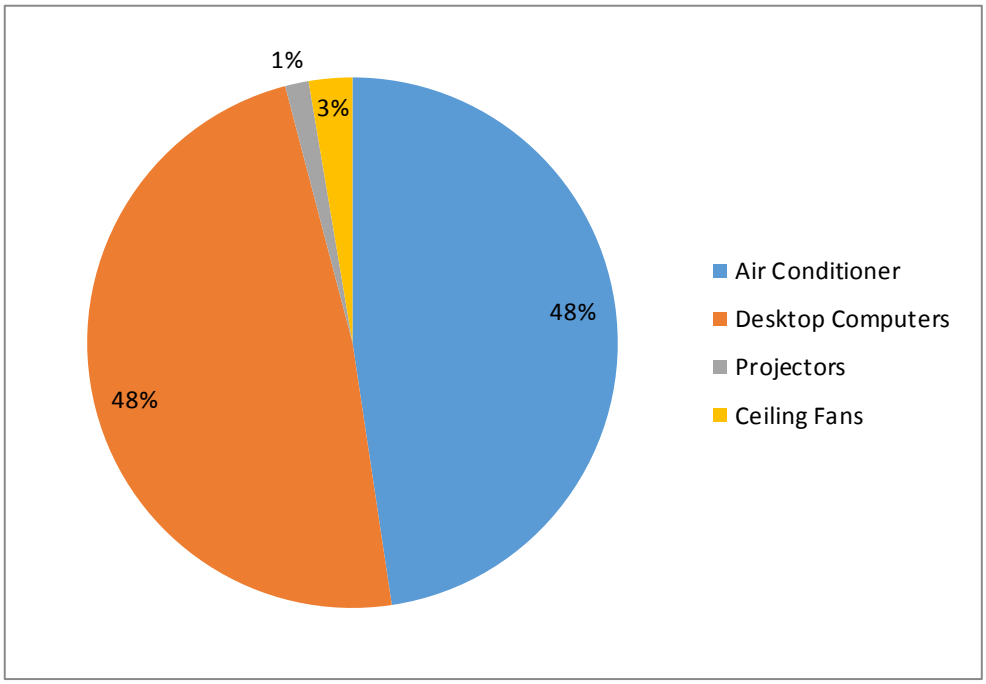


Figure 4.4: Electrical Equipment Summary Pie Charts of BRAC University Building 4

From the above pie charts we can see, air conditioner and the desktop computer shares equal consumption cost which is 48% of total electrical equipment cost. Then the rest altogether consumes 4%.

Table 4.3: Electrical bill date of building 4

Billing Month	**Value (BDT)**
July	3,20,455
August	4,02,923
September	3,51,911

The table 4.3 show the bill amount of three months and their average total for 3 months equals to BDT 3, 58,430.

So the following pie chart illustrates the percentage of each system as a part of the monthly bill.

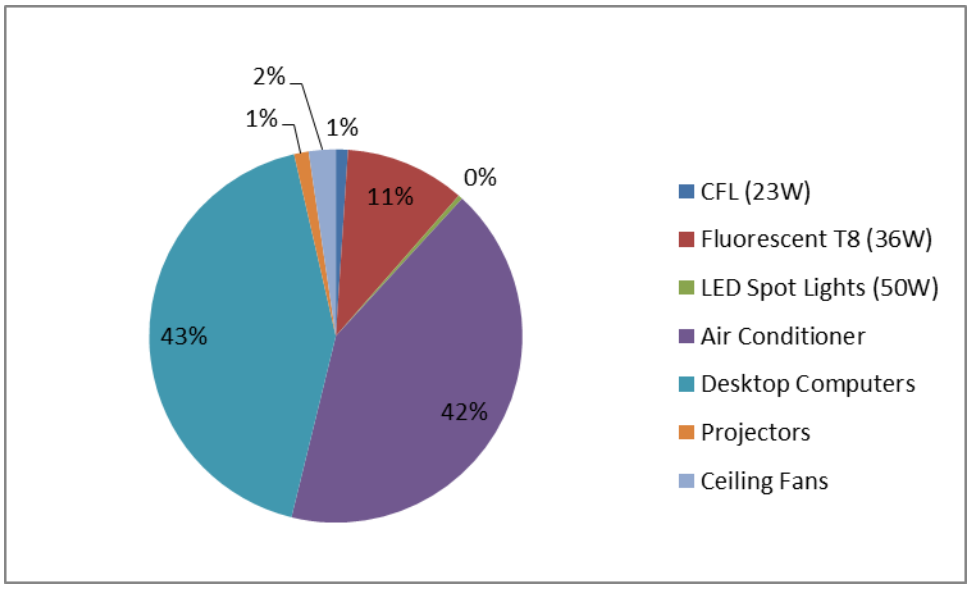


Figure 4.5: Summary Pie Charts of BRAC University Building 4with respect to actual monthly bill.

Therefore, we estimated that about 43% and 42% of the entire one month's cost corresponds to the most used equipment of the building which is desktop computer and air conditioner respectively. I would like to comment on this estimation and that is in this research waste of energy through intangible means like envelop loss are not considered.

4.3 BRAC University Building 1 Audit

BRAC University building 1 is located at 66 Mohakhali C/A Dhaka. The building has the height of seven floors but it is six storied and it is north-west facing. The floors are about 3600 sq.ft each. The ground floor which has a height equal to two floors comprises of the cafeteria and the conference hall. Floors from first to the fourth had same floor plan consisting of five – six classrooms. Lastly, the top floor houses the administrative offices.

Classrooms and in other floors, T8 fluorescent lamps in a fixture of four are used. CFL are used in lobby, washrooms and in stairways.

There is at least one air conditioner for every classroom with a capacity of 4 TON, along some ceiling fans in the hallway areas.

At least one desktop computer with a projector is available in every classroom and few more PCs in the offices.

4.4 Calculations of BRAC University Building 1

The following table shows the total lighting load and electrical equipment load of the building:

Table 4.4: Electrical Equipment and Lighting Load along monthly cost data in a concise way

Equipment Type	Quantity	Load (kW)	Monthly Energy Consumption (kWh)	Monthly Cost (BDT)
CFL (23W)	30	0.69	138	৳1,322
Fluorescent T8 (36W)	720	25.92	5184	৳49,663
Air Conditioner	26	104	20800	৳199,264
Desktop Computers	34	11.9	2380	৳22,800
Projectors	25	8.25	1650	৳15,807
Photocopiers	2	1.23	246	৳2,357
Ceiling Fans	17	1.36	272	৳2,606

The monthly cost of lighting load and electrical equipment totals to about BDT 2,93,813.

Here, is a pie chart representation of the data above in percentage.

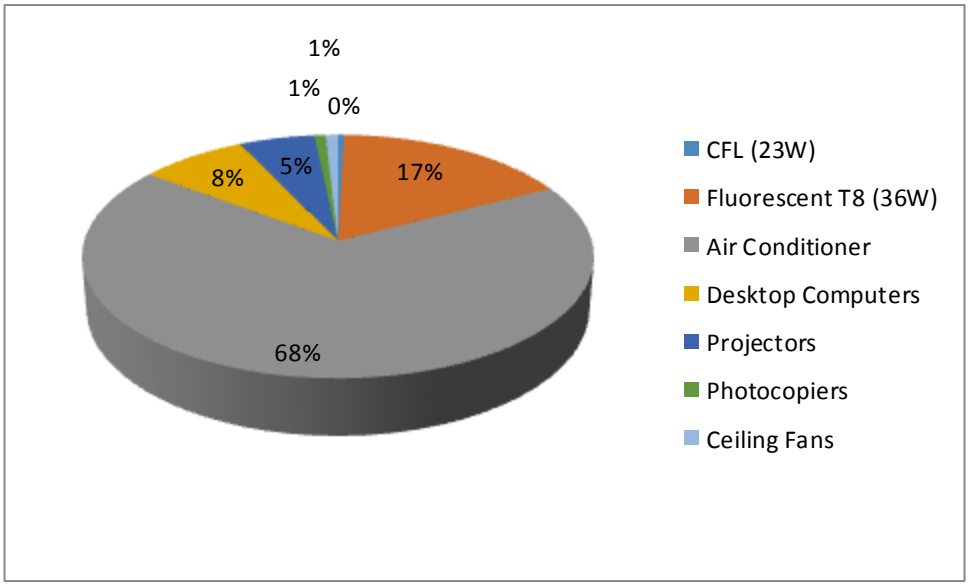


Figure 4.6: *Summary Pie Charts of BRAC University Building 1 with respect to actual monthly bill*

4.4 Yeasmin Tower Audit

The commercial building named Yeasmin Tower is located at House# 6/A, Road# 116, Gulshan Dhaka. It has six floors and is north facing with the floor size of 3600 square foot. It is has a toy shop, furniture shop, clothing store and a restaurant. The building also has an elevator and water pump.

Lighting system:

The lights used in this building vary in different types namely CFL, Fluorescent T8 with warm and colored tubes, High Intensity Spot lights and small LED spot lights.

CFL lamps are mostly used in the common public areas such as in the staircase, lobby and on the ground floor. The toy shop was seen to have a large number of these lamps as well.

Air conditioning:

Each floor had at least three split air conditioning units. The capacity of which ranged from 1 TON – 5 TON but 4 and 5 TON were mostly used.

Other Equipment:

Among other equipment desktop computer, printer, close circuit camera, microwave oven, refrigerator was noticed.

4.5 Calculations of Yeasmin Tower

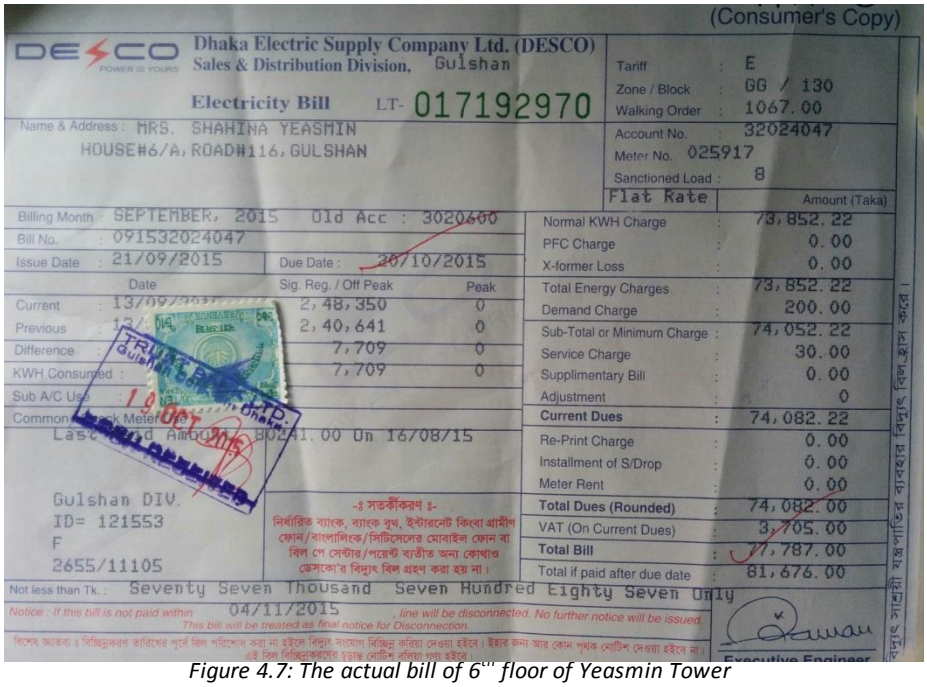
The data collected from this building is present in a floor wise scheme for a clear picture.

Table 4.5: Summary of all electrical and light load of Yeasmin Tower

Level	Electrical Equipment used	kWh Consumed (monthly)	Average Monthly Electricity bill
Ground Floor	• 2 water pump • 1 Lift (6 person capacity) • 6 cc camera • 12 CFL lamps	3100 kWh Estimated	BDT 30,000
Floor 1 (Toy Shop)	• 1 PC • 78 CFL lamps • 10 T8 Tube Lamps • Three 4 ton AC	6350 kWh	BDT 60,833
Floor 2 (Furniture Shop)	• 3 5 ton AC • 78 FL T8	Assuming 10000 kWh	BDT 95,800

	• 2 PC		
Floor 3 (Furniture Shop)	• Three 5 ton AC • 80 FL T8 • 1 PC	Assuming 10000 kWh	BDT 95,800
Floor 4 (Clothing Store)	• Three 5 ton AC • 83 T8 Tube lamps • 1PC	13120 kWh	BDT 1,25,690
Floor 5 (Clothing Store)	• Three 4 ton AC • 36 LED spot lights • 70 CFL lamps	8956.5kWh	BDT 85,803
Floor 6 (Restaurant)	• Three 4 ton AC • One 1 ton AC • 43 50W LED Lights • 2 Air Cutter • 10 23W CFL Lamp • 1 Microwave oven • 1 Desktop Computer • 1 Refrigerator	7075.80 kWh	BDT 80,346
Total per month		58602.3kWh	BDT 5,61,410

The table 4.5 represents the summary of all the electrical load and lighting load along with the estimated cost per month. It is necessary to say the information for floor 6 is as per actual bill data. Calculated bill amounts of other floors are based on interview conducted with the shop representatives and on observed load conditions.


(Consumer's Copy)

DESCO Dhaka Electric Supply Company Ltd. (DESCO)
Sales & Distribution Division, Gulshan

Electricity Bill LT- 017192970

Name & Address : MRS. SHAHINA YEASMIN
HOUSE#6/A, ROAD#116, GULSHAN

Tariff : E
Zone / Block : GG / 130
Walking Order : 1067.00
Account No. : 32024047
Meter No. 025917
Sanctioned Load : 8

Billing Month : SEPTEMBER, 2015 Old Acc : 3020600
Bill No. : 091532024047
Issue Date : 21/09/2015 Due Date : 30/10/2015

	Date	Sig. Reg. / Off Peak	Peak
Current	13/09/2015	2,48,350	0
Previous	12/08/2015	2,40,641	0
Difference		7,709	0
KWH Consumed		7,709	0

Sub A/C Use :
Common Meter Use :
Last Paid Amount 80241.00 On 16/08/15

Gulshan DIV.
ID= 121553
F
2655/11105

-ঃ সতর্কীকরণ ঃ-
নির্ধারিত ব্যাংক, ব্যাংক বুথ, ইন্টারনেট কিংবা গ্রামীণ ফোন/বাংলালিংক/সিটিসেলের মোবাইল ফোন বা বিল পে সেন্টার/পয়েন্ট ব্যতীত অন্য কোথাও ডেসকো'র বিদ্যুৎ বিল গ্রহণ করা হয় না।

Flat Rate	Amount (Taka)
Normal KWH Charge	73,852.22
PFC Charge	0.00
X-former Loss	0.00
Total Energy Charges	73,852.22
Demand Charge	200.00
Sub-Total or Minimum Charge	74,052.22
Service Charge	30.00
Supplimentary Bill	0.00
Adjustment	0
Current Dues	74,082.22
Re-Print Charge	0.00
Installment of S/Drop	0.00
Meter Rent	0.00
Total Dues (Rounded)	74,082.00
VAT (On Current Dues)	3,705.00
Total Bill	77,787.00
Total if paid after due date	81,676.00

Not less than Tk. : Seventy Seven Thousand Seven Hundred Eighty Seven Only

Notice : If this bill is not paid within 04/11/2015 line will be disconnected. No further notice will be issued.
This bill will be treated as final notice for Disconnection.

বিশেষ আকর্ষণ ঃ বিচ্ছিন্নকরণ তারিখের পূর্বে বিল পরিশোধ করা না হইলে বিদ্যুৎ সংযোগ বিচ্ছিন্ন করিয়া দেওয়া হইবে। ইহার জন্য আর কোন পৃথক নোটিশ দেওয়া হইবে না।

Executive Engineer

বিদ্যুৎ সাশ্রয়ী যন্ত্রপাতির ব্যবহার বিদ্যুৎ বিল হ্রাস করে।

Figure 4.7: The actual bill of 6th floor of Yeasmin Tower

4.4 Energy Footprint of the Selected Buildings

The estimated energy footprint is based on the estimated annual electricity energy use for your building divided by the estimated square footage. The estimated energy footprint enables us to compare the audited building to similar buildings for energy use. For example, if we have a retail building, the energy footprint is compared to the average energy footprint of buildings in the same building category: retail.

The more efficient a building is, the lower the building's energy use per square foot and thus the lower the building's estimated energy footprint. As the building becomes more efficient, the energy use intensity (kBtu/square foot) decreases. The higher the building's energy footprint, the less efficient and more costly it will be to operate the building.

The following table documents the information collected from the energy audit of the three buildings. Annual estimate energy consumption is interpolated from the collected data, which is then used to calculate the energy footprint of the buildings.

Table 4.6: Estimating energy footprint

	Floor Area (square foot)	Estimated Annual Energy consumption (kBtu)	Energy footprint (kBtu/square foot)
BRACU Building 4	3583.13	266503.3	74.03
BRACU Building 1	3600	1255804.6	348.80
Yeasmin Tower	3600	2399512.2	666.53

As we can see the energy footprint of the audited commercial buildings are represented above. Here, we can get a clear comparison factor to easily locate a building which is more efficient compared to others.

Based on the audit conducted along certain limitations, it is concluded that BRAC Building 4 is the most efficient among the three.

4.5 Comments

A primary challenge faced during the audit was that all the consumed electricity cannot be measured using equipment's rated values. The energy consumption of these equipments are classified as miscellaneous. For example, air conditioners - have internal control system which regulates the operation of the compressor in order to make it efficient. So here in our calculation, we assumed that the compressor was running through the period whereas in actual scene it does not and that creates difference in actual bill with the estimated bill. Henceforth, our calculated value is close to the original energy bills and we can assume an error percentage of our calculation to be approximately +20 to -20% due to the above mentioned problems.

5. CONCLUSION

The demand energy has been never dwindling and that we cannot live without electricity as of today it became quite obvious. Despite the fact that increases in resource consumption could have them one day depleted so we must strive to harness the waste energy by implementing more efficient structures. Although, energy auditing cannot produce exact solution to mitigate the consumption but brings out several possibilities for improving our usage which as a result may produce a good proportion of saving. The techniques and calculation methods used are for small scale audit only. In this study, we have mainly focused on BRAC University Building-1 and 4 and another commercial building named Yeasmin Tower with the objective of calculating energy usage, and loss to predict their operating efficiency. The operating efficiency is based on energy footprint which provides a numerical measure to compare similar for their energy uses. The tool 'EnergyWise'- that was developed estimates the annual consumption from lighting, electrical equipment and envelope sectors. Our study concluded that a proper energy audit can save reasonable amount of energy. However, many factors were avoided due to limitations of instrumentation.

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APPENDIXES

APPENDIX A. DATA COLLECTION FORMS

A.1 Lighting Audit Forms

Building Energy Audit

Lighting

Building Identification: _____ Floor No: _____

Please use a new sheet for each area, location or room in the facility.

Existing lights and controls

	Type 1	Type 2	Type 3	Type 4
Type of fixtures				
Number of fixtures:				
Number of lamps per fixture:				
If fluorescent indicate length of lamps (2 ft, 3ft, 4ft, 8ft):				
Watts per fixture: (Include ballast wattage if known)				
Fixture height from work surface(ft/m)				
Present operation of lights - hours/day				
Present operation of lights - days/week				
Present operation of lights – weeks/year				
Present operation of lights - hours/day				
Present operation of lights - days/week				

Present light levels: Bright_____ Adequate _____ Dim_____
Reflectance of walls and ceilings: Good_____ Average_____ Poor_____
Can lights be switched on and off as desired? Yes_____ No_____ Comment:_____
Can lower wattage lamps be installed? Yes____ No____ Comment:_____

Notes: _____

Lighting Legend

A.- Incandescent B.- Fluorescent T-12 C.- Fluorescent T-12 HO (High Output) D.- Compact Fluorescent E.- Mercury Vapour F.- Fluorescent T-12 VHO (VH Output) G.- High Pressure Sodium H.- Low Pressure Sodium I.- Metal Halide (White Light) J.- Fluorescent T-8 K.- Quartz Halogen L.- LED M. Other-specify _____

A.2 Envelope Audit Form

Building Energy Audit

Envelope

Building Info & Floor no:_____ **Direction Wall Faces**_____

For each wall area of facility (front, sides and back of a building) please use one sheet.

Windows

No of windows	Do windows open?	Window Area (sq-ft)	Type of glass used	Description of window type	Window fit (poor, fair, good)	Is there opening between window frames? Comment on airtightness.	Any Curtains Used? Type and color details

Doors

No. of doors	Is door Insulated? Airtightness (comment)	Description of door type	Condition of door	Is it Glass Door? Glass type..	Notes

Number/Location of broken or cracked windows:_____

_____

Description of door or window repairs or replacements needed (including door closers):_____

_____

Observatory Description

Wall Color, comments on wall condition _____

Floor type (mosaic, tiled, wooden, plain cemented) _____

Ceiling type and condition (bare ceiling, insulation used, decor, false foam ceiling):_____

_____

Comment on ventilation, space or opening _____

Air Conditioning

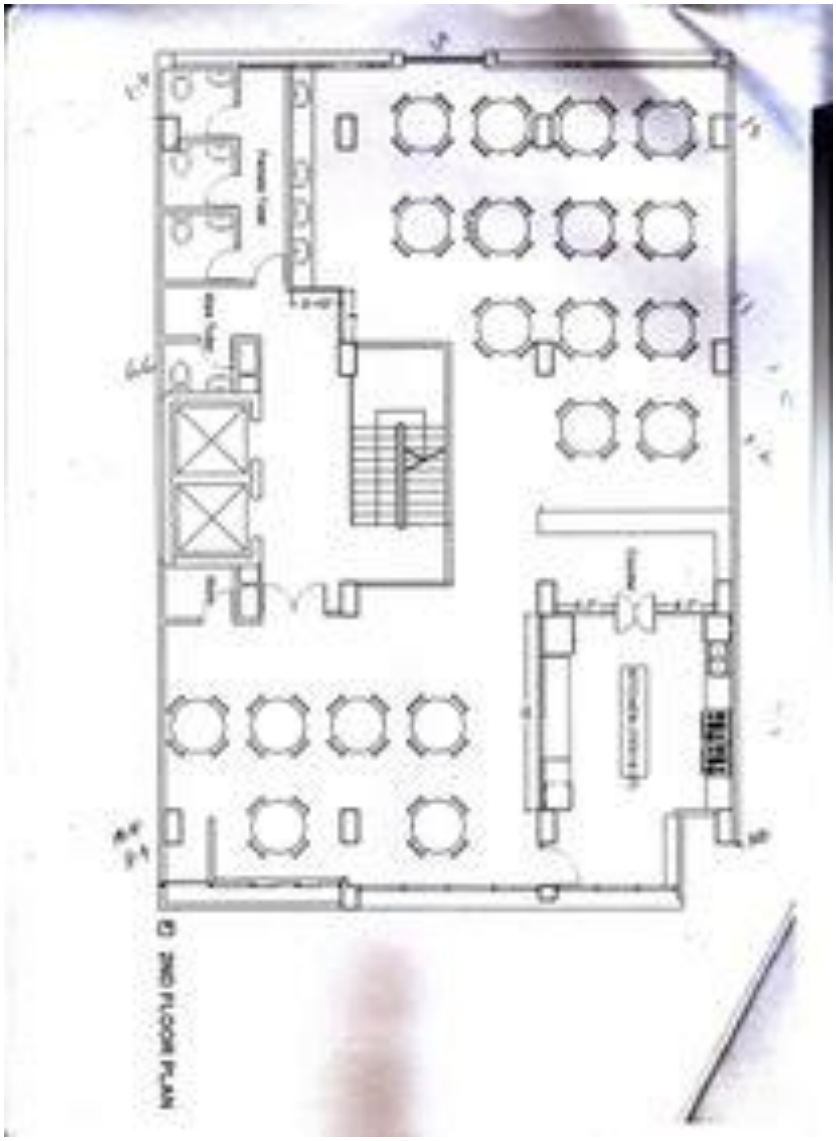
Number of units:_____ Make, type, size, location of each:_____

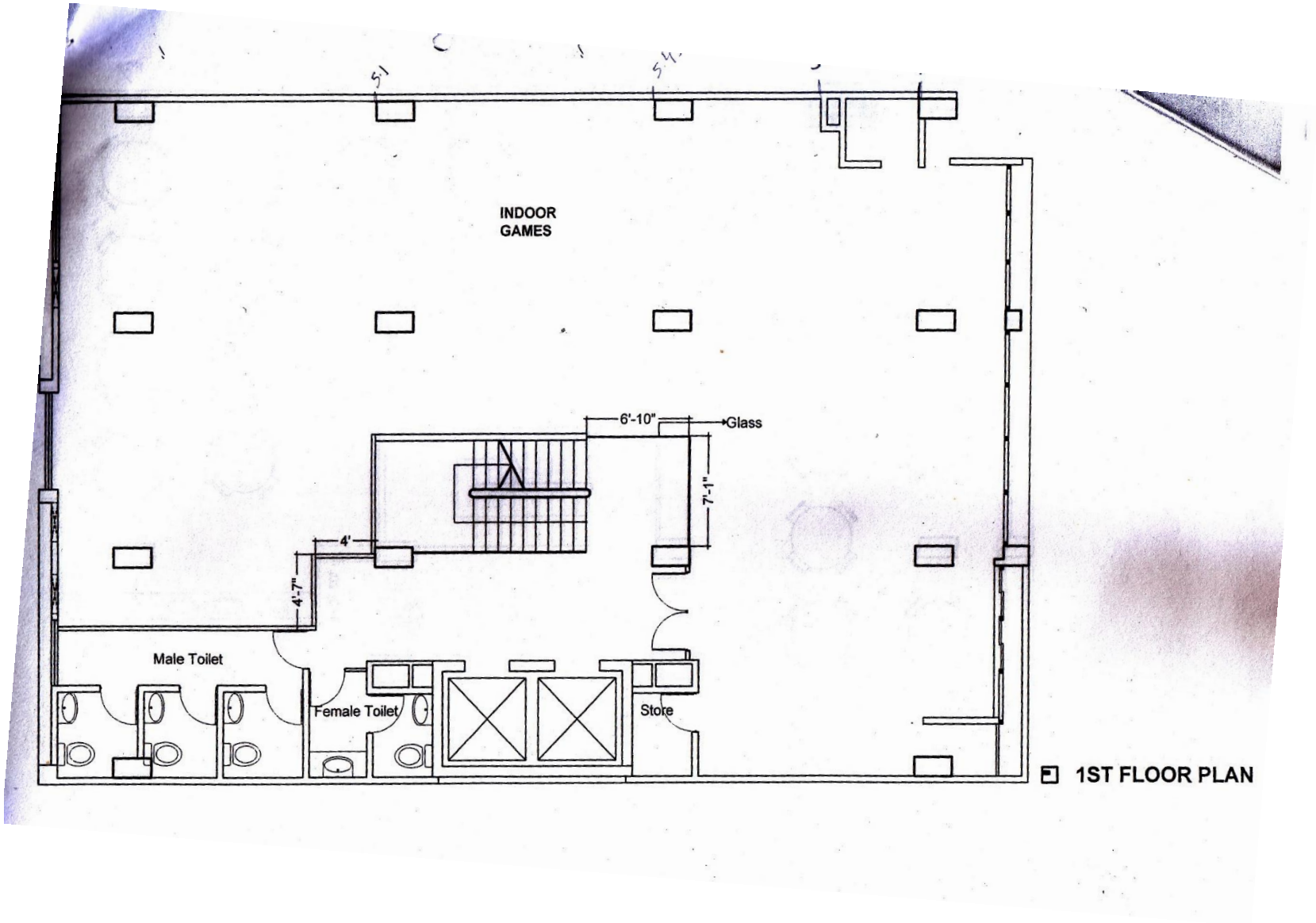
_____

Frequency of servicing:_____ Date of last servicing:_____

APPENDIX B. FLOOR PLAN

B.1 BRAC University Building 1





1ST FLOOR PLAN