ENERGY AUDIT REPORT

A Thesis submitted in partial fulfillment of the requirements for the Award of Degree of
Bachelor of Science in Electrical and Electronic Engineering

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Certification

This is to certify that this thesis entitled "**ENERGY AUDIT REPORT**" is done by the following students under my direct supervision and this work has been carried out by them in the field work of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. The presentation of the work was held on 8th December 2019.

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Dedicated to

Our Parents

EXECUTIVE SUMMARY

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. 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 effective technique to obtain such level of understanding would be to perform an Energy Audit.

Daffodil International University (CSE Building) is a 10 storeyed building with a basement and parking area and allocated with two lifts which is used for office work and Computer Laboratories. This Building facing towards west side. Later they made changes of the plan inside the building for their own. Ground floor basically a lounge area, level 1&2 classroom, level 3 to 6 made up for official work and 7 and above made up for lab room. This building is based on 100% electricity and water. No Gas is used in this building.

As part of the Building Master Plan our team conducted an ASHRAE Level 1 Energy Audit to identify several energy conservation opportunities at the building. Upon completion of the inspection, we are confident that the Daffodil International University (CSE Building) has several no cost/low cost energy conservation opportunities it can pursue. These opportunities will support the Building's economic benefit to the region and are summarized in this report.

From December 2017 to November 2018, this building spent BDT 2836555 for electricity and April 2017 to March 2018 they sent BDT 190826 for water, their total utility cost BDT 3027381. In September 2018 they used maximum electric energy and it costs BDT 448209 and in July 2018(During the Semester) they used electrical energy which costs BDT 156525. This trend shows that they misuse the electrical energy on September 2018 but if they focused on July 2018, they must use electricity efficiently and can continue the same practices to reduces their utility costs approximately 33.78% of the 2018 electric consumption or approximately BDT 958188.28. It is anticipated that the cost of electricity will increase over time. If the cost of electricity increases, these projected savings will increase correspondingly. These savings are based on the current cost of electricity.

These savings could be re-invested in capital improvement projects, such as the replacement of electrical equipment to the more energy saving equipment, lighting system and maintenance. It is expected that the building can save enough money by replacing this. Upon the completion of this capital improvement this building can save more, and it will continue to grow.

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ABBREVIATIONS

ANN	*Artificial Neural Network*
ASHRAE	*American Society of Heating, Refrigerating, and Air-Conditioning Engineers*
PDB	*Power Development Board*
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*
FL	*Fluorescent Lamps*
FL	*Fluorescent light*
HER	*Heat Energy Rating*
HFO	*Heavy Fuel Oils*
HID	*High Intensity discharge 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*
SAP	*Standard Assessment Procedure*
SEER	*Seasonal Energy Efficiency Ratio*

CHAPTER 1

INTRODUCTION

1.1 Introduction

Electrical energy is one of the vital parts of our modern life. It plays an important role as an infrastructural input for economic development of a country. In all economic sectors, households and commercial, demand for electrical energy is extensive. Global primary energy grew strongly in 2017, led by natural gas and renewables, with coal's share of the energy mix continuing to decline. Primary energy consumption growth averaged 2.2% in 2017, up from 1.2% last year and the fastest since 2013. This compares with the 10-year average of 1.7% per year (1). This indicates that mostly our energy is supplied by fossil fuels or from crude oils, both are non-renewable. Although many alternatives such as-wind, solar, geothermal, tidal, wave and biomass energy concepts have developed as renewable source; no sustainable solution to reduce dependency on fossil fuels has developed yet!

In Bangladesh maximum demand of electricity increased to 12644 MW which is change over the previous year 9.62%. According to Bangladesh power development board (2) pick generation is 9479 MW and it changed 4.90% from the previous year. The installed power generation capacity is about 13,555 MW, out of which 250 MW (1.84%) is generated by coal-fired power plants,8810 MW (64.99%) gas power plants, 3665 MW (27.04%) from Furnace oil and Diesel, 230 MW from hydro power stations and 600 MW (4.43%) are imported as of annual report 2016-2017. Regardless of this, Bangladesh still suffers from major shortage of electricity generation to satisfy the daily demand.

A long-term plan of electricity generation against the demand up to 2030 has been incorporated in the PSMP 2010 (2). Under the plan, generation capacity requirement in 2021 will be 24,000 MW against the demand of 20,000 MW and in 2030 generation capacity will be 39,000 MW against the demand of 33,000 MW. Around 50 % power will be generated from the domestic and imported coal and 23 % will be generated from Gas /LNG out of the total generation capacity 39,000 MW in 2030.

Till now, generation from gas is much higher than compare to other fuel like hydro, coal. For this reason, government has taken strategic decision to diversify primary fuel supply for power generation. In line with this strategy, a sustainable long-term power development plan has been prepared for mitigation the growing demand to reach the generation capacity 24000 MW by 2021 (2). Under this plan, the coal (indigenous or imported), imported power from neighboring countries, the limited domestic gas, nuclear power and LNG, renewable will be used for power generation. Government has also taken energy efficiency and conservation program for reduction of the growing power demand. Revised generation expansion plan updated in August 2016 targeting about 18,000 MW generation additions from 2017 to 2021.

Energy conservation and improvement of efficiency can be the cheapest and fastest solution to overcome all the energy demands. Energy conservation means reduction in energy usage by less energy service and energy efficient means less energy for a constant output. Although the two concepts differ from each other but can me merged by Energy Audit. Energy Audit is an assessment, survey and analysis of energy flows for energy conservation in a building, to reduce the amount of energy input into the system without having adverse effects on output. Energy Audit is one of the fundamental and necessary components to save energy bills and to conserve national energy resources of a country.

1.2 Objectives

The objectives of this audit work are

- To investigate whole building’s electrical equipment’s and its electrical connection.
- To study billing information
- To reduce energy uses
- To design single line diagram of electrical connection

1.3 Scopes

A country like Bangladesh, which has a population over 163 million and greatly relies upon natural resources for power generation; energy audit can be an effective tool to intuit and accomplish a comprehensive energy management program.

The issue of energy consumption has been a growing interest across all industry sectors not only because of its immediate impact on production costs but also because of its considerable impact on environmental sustainability (3).

In continuation of energy conservation energy audit is first steps. we intend to measure the energy, efficiency of various types of building in Bangladesh.

1.4 Methodology

The methodology is as follows:

The preliminary phase involved information gathering from logbook data sheets, historical data, drawing, literature and through interviews and discussion with electrical technician.

Current operating data for key parameters influencing energy efficiency obtained from control panel.

Specific energy conservation options were identified, along with a technical and economic feasibility analysis.

Basically, we did level 1 & level 2 audit of CSE building, DIU. Firstly, our audit team physically visited this building for taking all information of whole building. We took each floor size with specific electrical appliances. For better comparison we collected twelve months electricity and water bill copy.

1.5 Audit work Outline

This audit is organized as follows:

Chapter 1 Introduction of Energy Audit

Chapter 2 Reviews the literature

Chapter 3 CSE building analysis

Chapter 4 Energy use analysis

Chapter 5 Energy Savings opportunities

Chapter 6 Findings.

CHAPTER 2

LITERATURE REVIEWS

2.1 Introduction

The issue of energy consumption has been a growing interest across all industry sectors not only because of its immediate impact on production costs but also because of its considerable impact on environmental sustainability.

2.2 Energy Audit Definition

The purpose of an energy audit (sometimes called an "energy assessment" or "energy study") is to determine where, when, why and how energy is used in a facility, and to identify opportunities to improve efficiency. Energy auditing services are offered by energy services companies (ESCOs), energy consultants and engineering firms. The energy auditor leads the audit process but works closely with building owners, staff and other key participants throughout to ensure accuracy of data collection and appropriateness of energy efficiency recommendation. The audit typically begins with a review of historical and current utility data and benchmarking of your building's energy use against similar buildings. This sets the stage for an onsite inspection of the physical building. The main outcome of an energy audit is a list of recommended energy efficiency measures (EEMs), their associated energy savings potential, and an assessment of whether EEM installation costs are a good financial investment. (4)

In Bangladesh, the energy efficiency and conservation rules were passed in 22nd October 2012 from the Ministry of Power, Energy and Mineral Resources. The draft illustrates on energy audit and conservation on its section 4, clearly stating that all the commercial buildings must comply the rules and use efficient, and cost-effective life cycle appliances following Bangladesh National Building Code (BNBC) (5). Although rules on energy audits were from 2012, comprehensive studies have not been published accordingly in Bangladesh.

2.3 Types of Energy Audit

Energy audits typically take a whole building approach by examining the building envelope, building systems, operations and maintenance procedures, and building schedules. Whole building audits provide the most accurate picture of energy savings opportunities at your facility.

Alternately, energy audits can be targeted to specific systems (i.e., lighting or heating, ventilation and air conditioning). Targeted audits may miss significant bigger picture energy savings opportunities but may be a good route if you have specific energy efficiency retrofit projects in mind and limited funds to invest.

2.4 Levels of Energy Audit

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) defines three levels of audits. Each audit level builds on the previous level. As audit complexity increases, so does thoroughness of the site assessment, the amount of data collected, and the detail provided in the final audit report. This effort can translate into higher energy savings.

Level 1: Site Assessment or Preliminary Audits identify no cost and low-cost energy saving opportunities, and a general view of potential capital improvements. Activities include an assessment of energy bills and a brief site inspection of your building.

Level 2: Energy Survey and Engineering Analysis Audits identify no cost and low-cost opportunities and provide EEM recommendations in line with your financial plans and potential capital-intensive energy savings opportunities. Level II audits include an in-depth analysis of energy costs, energy usage and building characteristics and a more refined survey of how energy is used in your building.

Level 3: Detailed Analysis of Capital-Intensive Modification Audits (sometimes referred to as an "investment grade" audit) provide solid recommendations and financial analysis for major capital investments. In addition to Level I and Level II activities, Level III audits include monitoring, data collection and engineering analysis (6).

From above discussion levels of energy audit can be summarized in table 1

Table 1: Audit Phase

Auditing Level	Activities
Level 1: Walkthrough Audit	1. Collect and analyze utility data 2. Assess energy efficiency improvement potential 3. Visually inspect building and key system
Level 2: Standard Audit	1. Interview building staff 2. Evaluate utility and site data 3. Analyze energy and cost saving data
Level 3: Detailed Energy Audit	1. Develop simulation tool 2. Summarize findings 3. Present recommendations 4. Prepare professional report

CHAPTER 3

BUILDING ANALYSIS

3.1 Introduction

DIU CSE building is a 10 storeyed building with a basement and parking area having total floor area 19738 square feet. Building situated in Mirpur Road, Dhanmondi facing towards west side. Building have two passenger lift. Ground floor basically a lounge area, level 1&2 are classroom, level 3 – 6 made up for official work and level 7 – 10 made up for classroom and lab room.

Building energy demand 100% meet-up by electric, no gas or renewable energy has been used. Two backup diesel Generators has been connected to main electricity incoming. Building is open for academic work from 08.30 to 5.30 during daytime and five days per week (Saturday to Thursday) except university holydays.

3.2 General Description

The Construction of CSE Building was originally completed in 2013. It is a commercial building and DIU authority use it for academic purpose. The CSE building's weekly operating hours are listed in Table-2

Table 2: CSE Building Weekly Operation Hours

Time	Sat	Sun	Mon	Tue	Wed	Thu	Total hours In week
Open	0830	0830	0830	0830	0830	0830	54
Closed	1730	1730	1730	1730	1730	1730	

3.3 CSE Building Floor Area

The gross square footage is approximately 19738 square feet (SF). The buildings and there respective areas are shown in Table-3

Table 3- Floor Area

Room Area	Square Feet
Lab Room	829
Lab Room	865
Cori Door	79.8
Lift Area	80
Stairs	40
IT Office	80
Total in one floor	1973.8
Gross total	19738

3.3.1 Floor Layout

During observation, we noted how many appliances connected in a single room and actual size of the room in floor. Here in Figure-1, we draw the schematics diagram of 9th floor of this building.

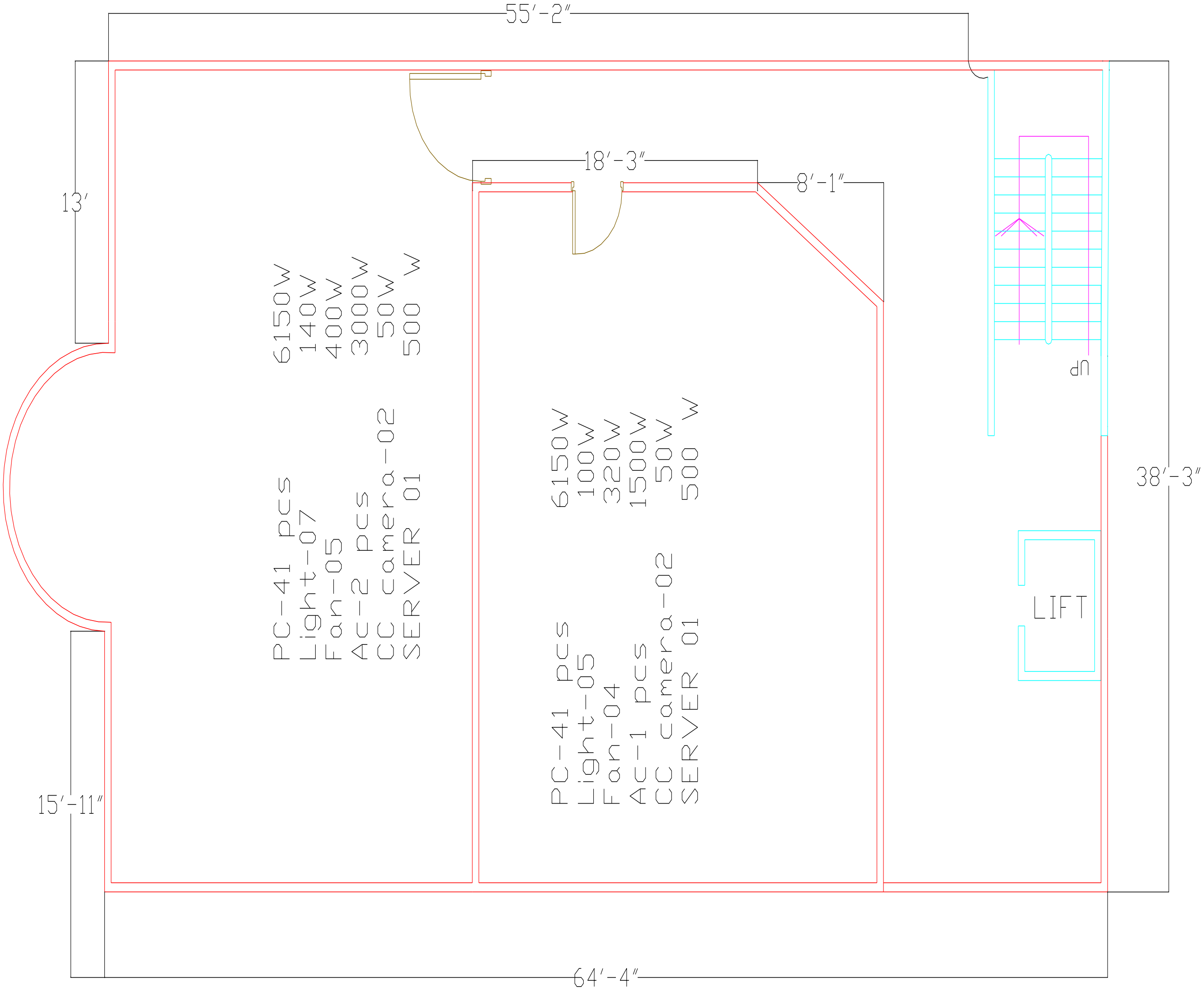

Figure 1: Schematics diagram of 9th floor of CSE Building, DIU

3.4 Single Line Diagram of CSE Building, DIU

We physically visited and collected all data and readings from transformer and other appliances. DPDC Medium Voltage (MT) 11 KV line connected as a power source of the building. There are two generators for backup. One is 220KV and another is 110KV. Details single line diagram is given below in Fig-2

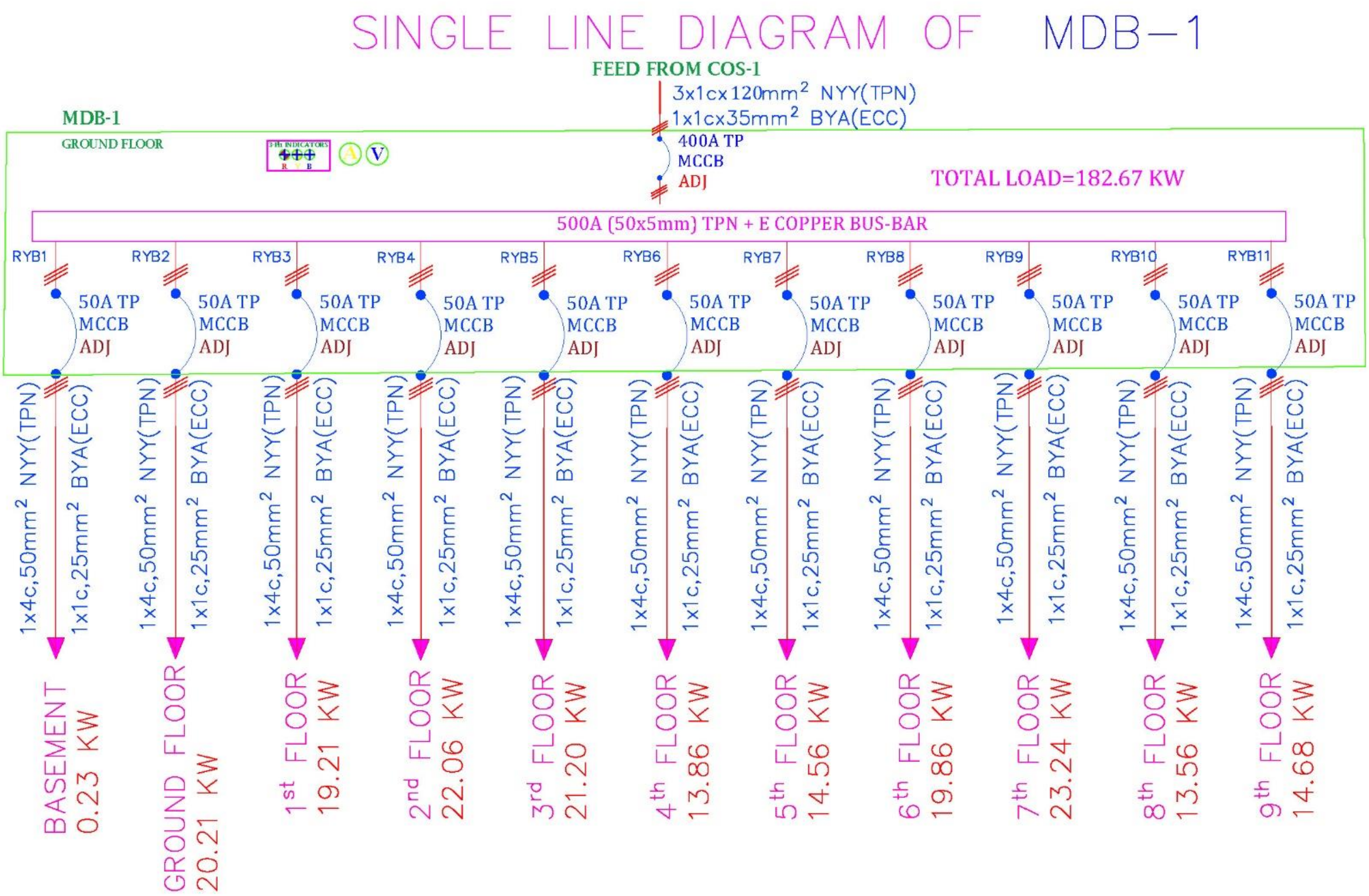

Figure 2: Single line diagram of CSE building, DIU

CHAPTER 4

ENERGY USE ANALYSIS

A visual inspection of accessible areas of the Building, lift operating room, class & lab and the generator room. Electrical systems, the lighting, and the domestic water systems were inspected. Although the equipment has been well maintained, it can be upgraded to improve the efficiencies of the Air Conditioning systems. All existing Air Conditioning units appeared to be operating during the visit. However, it was observed that several are not operating in the manner that they were designed.

We used the value related to monthly energy consumption to calculate specific energy consumption (SEC). SEC is an important tool for comparative analysis within an industry or sector. The value helps in determining the month/annual energy usage. It gives an idea of the overall energy usage, energy intensity and helps in setting achievable benchmark for the building based on existing equipment and process.

4.1 Lighting Audit

We checked all rooms of the building. There are only T5 and LED lights are connected. We did light audit of the whole building.

- We Collected Lighting Information For each area
- Hours of operation Type of lamps
- Availability of daylight
- Area dimensions

Table 4: Lighting connected in building

Room No/Type	Room Area (L) ft	Room Area (W) ft	Room area (ft^2)	Type of Light	Wattage (Watt)	Quantity of Light (Pcs)	Luminus output (Lm)	Hours on during day	Hours on during a year	Energy Use/Yr (kWh)	Effective Lumens
Computer Lab	35	23.7	829.5	T5	28	6	480	9	2592	435.456	240
Computer Lab	32.8	26.4	865.92	T5	28	5	400	9	2592	362.88	200
Cori door	8	5	40	T5	28	2	160	9	2592	145.152	80
Cori door	14	5.7	79.8	Led Light	23	2	200	9	2592	119.232	100
IT office	10	8	80	T5	28	2	160	9	2592	145.152	80
Computer Lab	35	23.7	829.5	T5	28	6	480	9	2592	435.456	240
Computer Lab	32.8	26.4	865.92	T5	28	5	400	9	2592	362.88	200
Cori door	14	5.7	79.8	Led Light	23	2	200	9	2592	119.232	100
Cori door	8	5	40	T5	28	4	320	9	2592	290.304	160
Washroom	10	8	80	T5	28	1	80	9	2592	72.576	40
Computer Lab	35	23.7	829.5	T5	28	7	560	9	2592	508.032	280
Computer Lab	32.8	26.4	865.92	T5	28	6	480	9	2592	435.456	240
Stuff Room	10	8	80	T5	28	1	80	9	2592	72.576	40
Cori door	14	5.7	79.8	Led Light	23	2	200	9	2592	119.232	100
Cori door	8	5	40	T5	28	2	160	9	2592	145.152	80
Computer Lab	35	23.7	829.5	T5	28	7	560	9	2592	508.032	280
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Washroom	10	8	80	T5	28	1	80	9	2592	72.576	40
Computer Lab	35	23.7	829.5	T5	28	7	560	9	2592	508.032	280
Computer Lab	32.8	26.4	865.92	T5	28	6	480	9	2592	435.456	240
Cori door	14	5.7	79.8	Led Light	23	2	200	9	2592	119.232	100
Cori door	8	5	40	T5	28	2	160	9	2592	145.152	80
IT office	10	8	80	T5	28	2	160	9	2592	145.152	80
Faculty Room	40	35	1400	T5	28	16	1280	9	2592	1161.216	640
Washroom	10	8	80	T5	28	2	160	9	2592	145.152	80
Cori door	14	5.7	79.8	Led Light	23	2	200	9	2592	119.232	100
Faculty Room	40	35	1400	T5	28	13	1040	9	2592	943.488	520
Washroom	10	8	80	T5	28	1	80	9	2592	72.576	40
Cori door	14	5.7	79.8	Led Light	23	2	200	9	2592	119.232	100
Office Room	7	5	35	T5	28	9	720	9	2592	653.184	360
Office Room	7	5	35	T5	28	3	240	9	2592	217.728	120
Office Room	7	5	35	T5	28	3	240	9	2592	217.728	120
IT office	8	5	40	T5	28	3	240	9	2592	217.728	120
Cori door	14	5.7	79.8	Led Light	23	2	200	9	2592	119.232	100
Staff Room	6	5	30	T5	28	6	480	9	2592	435.456	240
Wash Room	10	8	80	T5	28	1	80	9	2592	72.576	40
Office Room	32.8	26.4	865.92	T5	28	7	560	9	2592	508.032	280
Classroom	35	23.7	829.5	T5	28	5	400	9	2592	362.88	200
Washroom	10	8	80	T5	28	2	160	9	2592	145.152	80
Cori door	14	5.7	79.8	Led Light	23	2	200	9	2592	119.232	100
Cori door	8	5	40	T5	28	2	160	9	2592	145.152	80
Classroom	35	23.7	829.5	T5	28	5	400	9	2592	362.88	200
Classroom	32.8	26.4	865.92	T5	28	7	560	9	2592	508.032	280
Washroom	10	8	80	T5	28	2	160	9	2592	145.152	80
Cori door	14	5.7	79.8	Led Light	23	2	200	9	2592	119.232	100
Cori door	8	5	40	T5	28	2	160	9	2592	145.152	80
Staff Room	6	5	30	T5	28	2	160	9	2592	145.152	80
IT office	8	5	40	T5	28	2	160	9	2592	145.152	80
Lounge	63	35	2205	Led Light	23	27	2700	9	2592	1609.632	1350
Security Room	6	5	30	T5	28	1	80	9	2592	72.576	40
Parking	64.4	38.3	2466.52	T5	28	7	560	9	2592	508.032	280
Total energy consumption by existing lighting system = **15938 kWh**											

In this Table-4 we explore each floor of this building and collect information what kind of lights are connected and about the wattage. Here we make a list in Table-5 below about whole lighting system.

Table 5: Type of connected light in building

Lamp Type	Quantity	Lighting Load (kW)	Yearly Energy Consumption (kWh)	Yearly Cost (BDT)
T5 (28W)	181	5.06	13137	108380
LED (23W)	47	1.08	2802	23116

Table-5 shows that T5 consumed 13137 kWh and its cost 108380 BDT. and LED consumed 2802 kWh and its cost 23116 BDT.

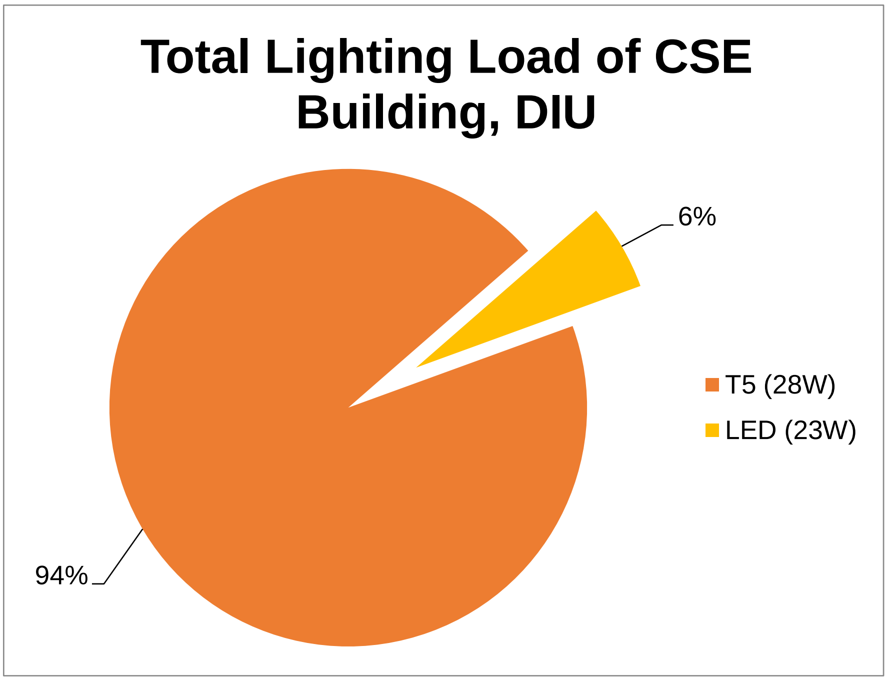

Figure 3: Total Lighting Load of CSE Building DIU

Figure 3 shows that yearly cost of different type lighting load Here is a pie chart of total lighting load of CSE building, DIU. T5(28W) 94% and LED (23W) is only 6%

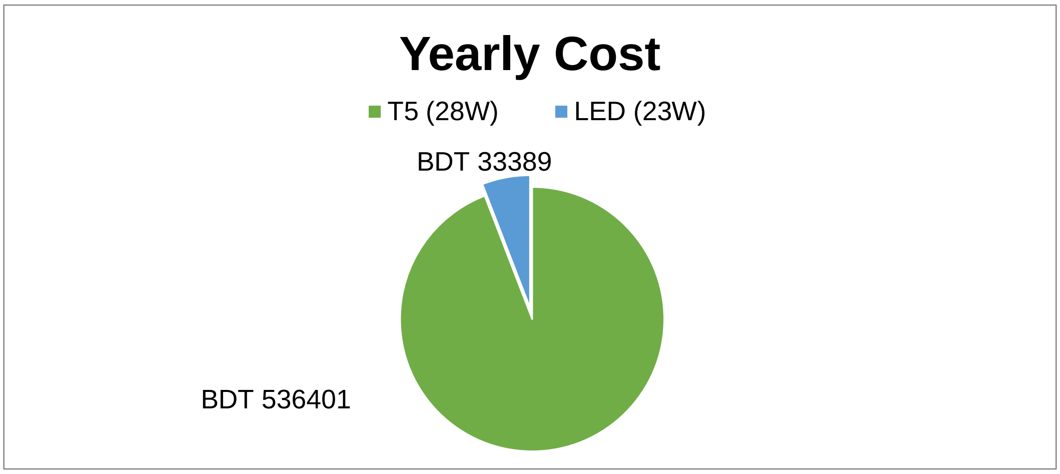

Figure 4: Yearly Lighting Cost of CSE Building DIU

Figure-4 shows that how may cost for lighting of this building. BDT33389 for LED LIGHT (23W) and BDT536401 for T5(28W).

4.2 Electrical Appliances Audit

Electricity is metered and billed based on the existing electric meter, #**612030138**. There are also, one sub-meter. The current tariff charges of 8.25 BDT/kW; consequently, it would be beneficial to look for ways to reduce the peak demand in the terminal. This analysis is beyond the scope of this report; however, there appears to be an opportunity to save additional energy. Here we will analysis last 1-year electricity bill in details, if there is some opportunity to save energies. The energy, water use, and cost history are shown in Table 6.1 below.

Table 6: Energy Use & Cost History

Year	Electric	
	Use(kWh)	Cost (BDT)
Jan 2018-Dec 2018	317947.0303	26,23,063

There are Various types of appliances are connected to the whole building. Among them we assume Lighting section, cooling and ventilation section, Utilities and Desktop with accessories section. Load type wise energy consumption are shown in Table-7.

Table 7: Load Type Wise Energy Consumption

Load Type	kWh
Lighting Load	939.15
Cooling & Ventilation	13746
Utilities	1369.5
Desktop & Accessories	20563.5

In pie chart we can see the all connected load in percentage. Most of the electricity is consumed by desktop (56%), Cooling and Ventilation (37%).

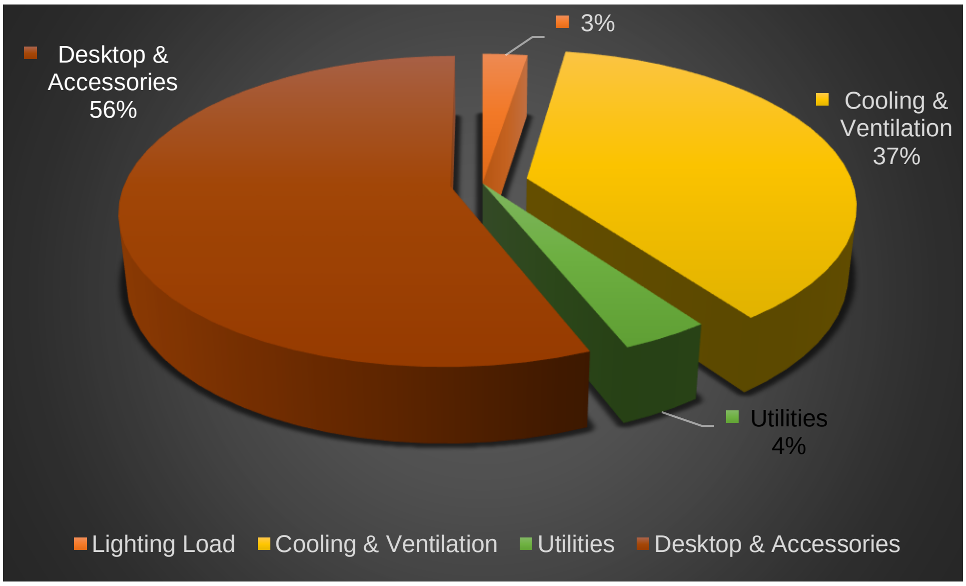

Figure 5: Load Type Wise Energy Consumption Pie Charts of CSE Building, DIU

Figure-5 shows all the connected load Electricity consumption in **kWh** in pie chart. As level 7 – 10 of this building made up for classroom and lab rooms, desktop and accessories consumed most & AC (31%) load are maximum load between all electrical appliances.

4.3 Electricity Bill Analysis

We collect last one-year energy bill from respective authorities for analysis.

Table 8: Month wise energy consumption of the CSE Building

	Month-wise Energy Consumption		
Month	Bill (BDT)	ER (AVG) (Tk/Unit)	Unit(kWh)
Jan-18	142823	8.25	17311.87879
Feb-18	176663	8.25	21413.69697
Mar-18	274566	8.25	33280.72727
Apr-18	205891	8.25	24956.48485
May-18	254429	8.25	30839.87879
Jun-18	185234	8.25	22452.60606
Jul-18	256128	8.25	31045.81818
Aug-18	200645	8.25	24320.60606
Sep-18	200645	8.25	24320.60606
Oct-18	248209	8.25	30085.93939
Nov-18	293273	8.25	35548.24242
Dec-18	184557	8.25	22370.54545
Total	**2623063**		317947.0303

We take energy rate BDT8.25 per unit according to DPDC (7) MT-2 Commercial & Office tariff rate by the means of pick time, off-pick time, flat rate and demand charge rate.

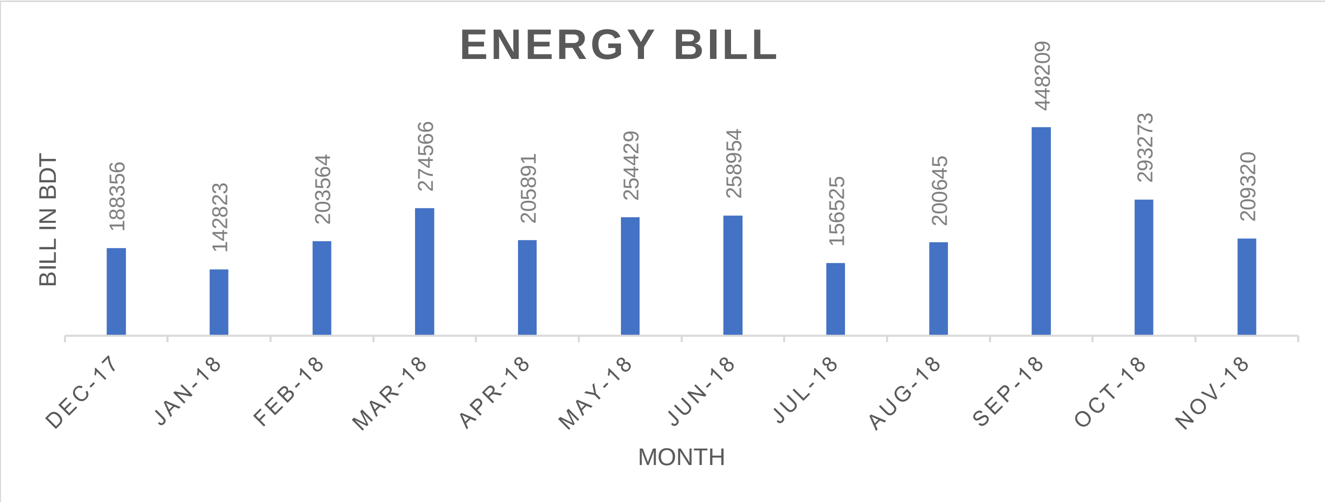

Figure 6: Bar chart of Month wise electricity bill

Electricity bill comparatively same. In summer season bill is about 9% but in winter it should more less than 8%. Because cooling load were turned off. In assumption we can say building staff were not aware about electricity uses. the electricity consumption is within the same range from January to August and increases from September to December. It also shows that energy consumption of last one-year (January 2018 to December 2018) by whole building. Electricity consumption in whole building is comparatively low in dec-18, jan-18, feb-18. These three months are under winter season. Cooling load like air conditioner & fan turned off or ac kept higher temperature only passing air for not suffocated. So, in this time energy consumption decreases. The building shows a typical profile of building electricity use with peaks during the summer cooling months.

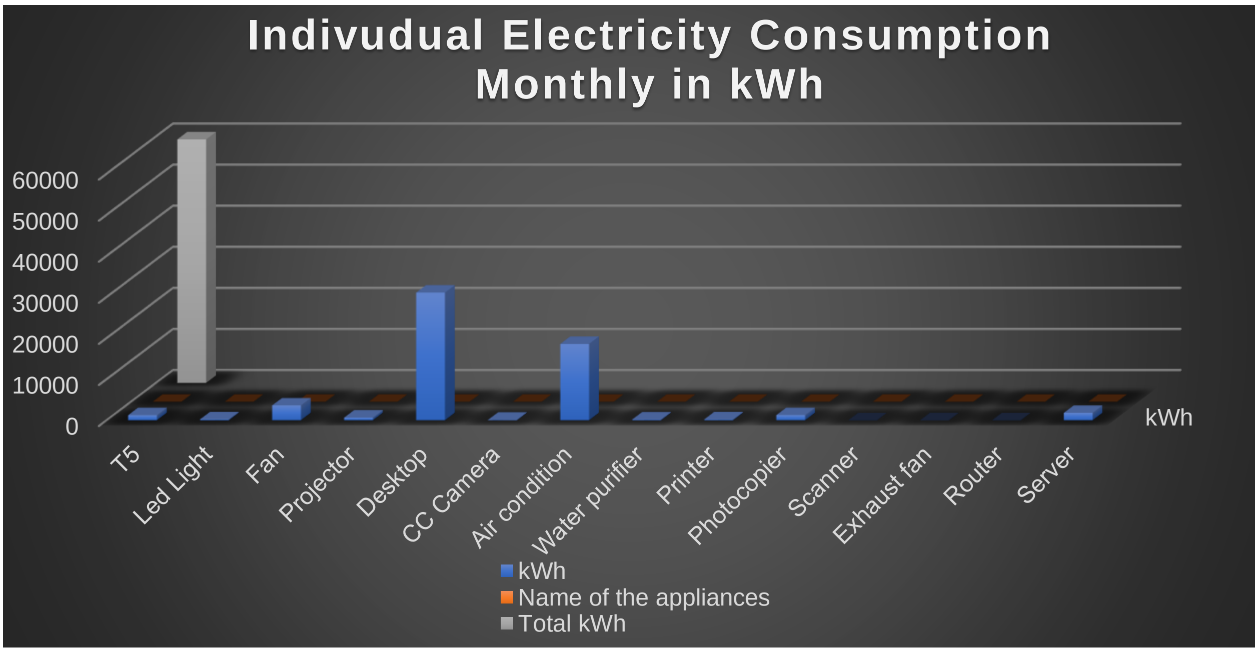

Figure 7: Bar chart of Month wise Individual electricity Consumption

In Fig-7, Monthly total consumed electricity is 59321.403 kWh. From total kWh Desktop and Air conditioner consumed most.

4.4 Benchmarking

Benchmarking of the commercial building Like Daffodil International University for energy efficiency is a challenging and debatable issue due to wide variations in the working environment. The variation can be due to geography, climate, manpower, working conditions etc. Therefore, first benchmarks the consultants propose are the minimum SEC already achieved by the building. This level of intensities cannot be disputed as the company has already achieved these under the existing conditions. It is important for the building authority to analyze the activities and practices of that month and drive the staff to replicate them going forward.

By benchmarking system, it shows that either building using more energy from other similar buildings or not.

Serial	Building Type	Built-Up Area, [m2]	Annual Energy Consumption [kWh]	EUI
OFFICE BUILDINGS				[kWh/m2/year]
1	One shift Building	16,716	20,92,364	149
2	Three shifts Building	31,226	88,82,824	349
3	Public Sector Building	15,799	18,38,331	115
4	Private Sector Building	28,335	44,98,942	258
5	CSE Building	1,834	3,17,947	173

Figure 8: Benchmarking of Energy use Index

Fig-8 shows the comparison between similar types building energy consumption. We can say that, our building's EUI is reliable.

CHAPTER 5

ENERGY SAVINGS

5.1 Introduction

This chapter will be explaining about the energy savings methods. Most of the electrical appliances we used are old and they are not energy efficient at all. Now a days there are many smart appliances available in market. So, we will discuss how we can reduce our energy consumption.

5.2 Energy Savings on Desktop

Previously in pie chart we saw from total energy about 53% energy consumed by Desktop. It's a huge amount energy. We can reduce this power consumption by replacing desktop by Laptop. Laptop consumed about 120W only. If we replace 512 desktops by laptop energy consumption will reduce significantly.

Laptop quantity-512,

Wattage-120W,

Total KW assumption by Laptop-61.44KW

Energy consumption by desktop =128 KW

Energy savings: (128-61.44) KW = 66.56 KW

Daily Desktop Running Time= 9H

Energy cost= (66.56x9x8.25)

=**4942** bdt daily & **133,436 bdt** monthly

We can reduce **52%** energy consumption by replacing desktops.

And in addition, if we want to replace this old 512 desktop by Laptop then Payback year will 11 years.

Investment Required	BDT 17,920,000
Annual Saving	BDT 1,601,232
Simple Payback Period	11 years

Figure 9 Payback Period for replacement of Desktop

5.3 Energy Savings on Lighting System

Analysis from previous load calculation and pie chart we can say that energy can save from whole lighting system. Now a days there are many energies saving light available in local market. Here will calculate how many energies we can save from lighting system.

Considering wattage of a T5(4 feet) = 28W

Wattage of LED lamps = 18W

The wattage difference we get = 28-18=10W

Number of tube lights = 185

Wattage Saving = 185×10=1850W=1.85 kW

Total working hours in a year = 2592

Savings in Unit=2592x1.85= 4795 kWh

Cost saving of electricity at 8.25bdt per kWh=4795 x 8.25 = **39559** BDT per year

The total annual energy cost for T5 lighting = **104380 BDT**. Therefore, after replacements with LED we can annually save

$= \frac{39559}{104380} * 100 = \mathbf{37.90\ \%}$

Table 9:Savings from lighting system

Name of the buildings	Types of lights used and corresponding Wattage	Replacement lights and corresponding Wattage	Savings after retrofits
CSE Building DIU	T5 (28 W)	LED (18 W)	37.90%

Table-9 Here we show the savings after replacement by LED

Investment = 650x185

=120250 BDT

Simple Payback period = 120250/ 39559

= **3.5** years

Table 10: Summary of Light Replacement

Investment Required	BDT 120250
Annual Saving	BDT 39559
Simple Payback Period	3.5 years

Table-10 shows that investment and simple payback period for Light

5.4 Energy Savings on (AC)

Table 11 compares the measured temperature and relative humidity (RH) to the ASHRAE Standard 55.

Table 11: Temperature Measurement

Season	Area	Operation Mode	Audit			ASHREE Standard 55		
			Temp.		RH%	Temp.		RH%
			F	C		F	C	
Summer	Classes & Lab	Cooling	68	20	80	73-79	23-26	50
	Outside		102.2	44	80	73-80	23-27	50
Winter	Classes & Lab	Cooling	71.6	22	65	73-81	23-28	50
	Outside		78.8	26	65	73-82	23-29	50

During audit we have got the temperature details on winter season, but we collected temperature details of summer season from accu weather site.

Terminologies used for calculation of saving from AC

Q_a= Quantity of air conditioner

WH_d = Working hours per day

WD_m = Working days per month

U_c = Unit cost of electricity for commercial building

P_{exist} = Power rating of existing appliance

P_{star} = Power rating of ENERGY STAR* rated appliance

P^{exist} =Power consumption of existing appliance

P_* = Power consumption of ENERGY STAR* rated appliance

P = Saving in power consumption

Saving calculation for CSE Building DIU for electrical appliances:

Saving from the replacement of conventional air conditioner by ENERGY STAR* rated air conditioner:

Q_a = 34, WH_d = 9hour, WD_m = 25 day, P_{exist} = 2250W, P_{star} = 1350W

Power demand for proposed AC = Qa ×Pstar

= 34 × 1350w

= 45.9 kW

Power demand for existing AC =Q × Pexist

= 34 × 2250

= 76.5 kW

U_c = **8.25** BDT

Power demand saving = P_{exist} consumption- P_{Star} consumption

= 76.5 - 45.9 = 30.6 kW

Saving in BDT/Month

= $P \times WH_d \times WD_m \times U_c$

= 30.6 × 9 × 25 × 8.25

=56801 BDT

And Annually **681612bdt**

So, we can save bdt**6,81,612** per year from AC only. As this replacement of all ac system is costly there is another way to save money as well as energies.

5.5 Energy Savings by Installing Rooftop Solar Plant

The need for electricity is increasing in all sectors and all over the world. But the conventional resource for production of electricity is decreasing day by day and it is so much harmful for the environment. Now whole world is going for reliable, sustainable and clean energy.

So we can install solar PV system on our building roof and can run small appliances load like Light, Fan. It will help us to reduce Uses of Electricity from Grid.

We can install **4KWp** solar PV System on Rooftop, Lets analysis this 4kWp rooftop solar PV System. We have $183m^2$ area on Rooftop

We will use Trina 320wP Module

Module quantity-13

Azimuth-130 Degree

Tilt Angle-23 degree

Row Spacing-1.8meter, Span/Rise-2.4

Module Spacing-05 Meter

Set Back from edge-1 meter

Inverter Size- 4kwP

5.5.1 Solar path at CSE Building, DIU using PVsyst Software

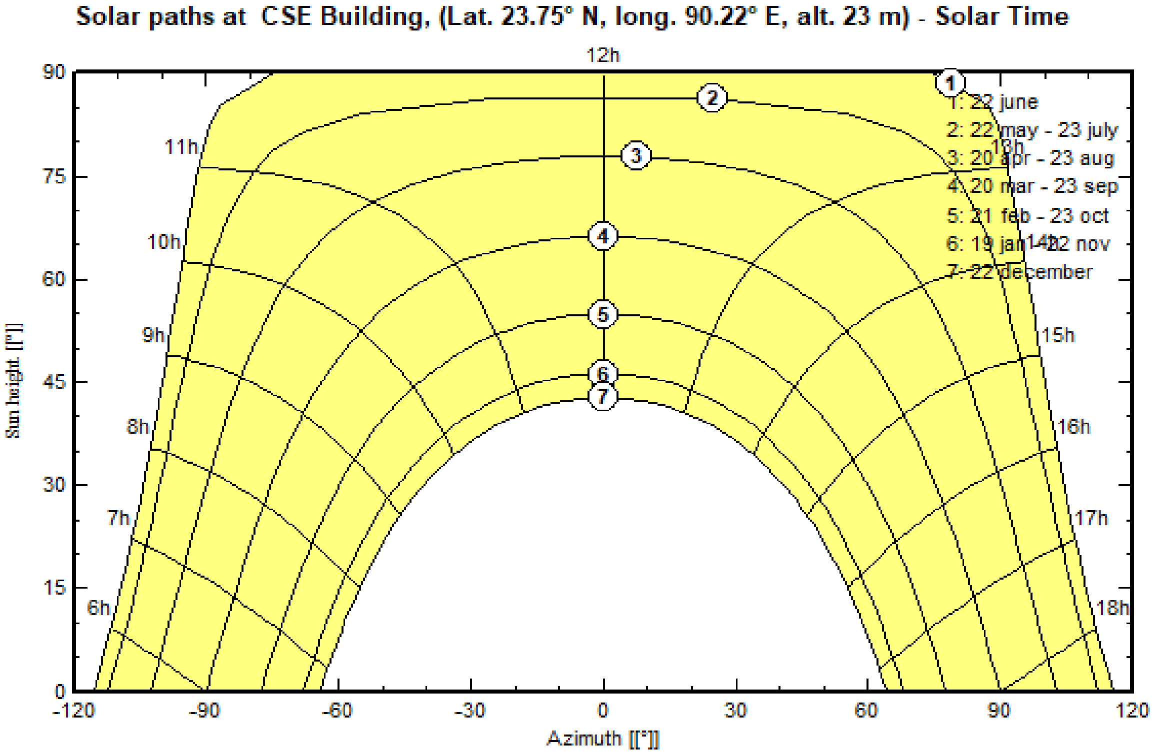

Figure 10: Analysis of Solar path at Project location

Sun path, sometimes also called day arc, refers to the daily and seasonal arc-like path that the Sun appears to follow across the sky as the Earth rotates and orbits the Sun. The Sun's path affects the length of daytime experienced and amount of daylight received along a certain latitude during a given season.

The relative position of the Sun is a major factor in the heat gain of buildings and in the performance of solar energy systems. Accurate location-specific knowledge of sun path and climatic conditions is essential for economic decisions about solar collector area, orientation, landscaping, summer shading, and the cost-effective use of solar trackers

5.5.2 3D Design of CSE Building in Helioscope Software

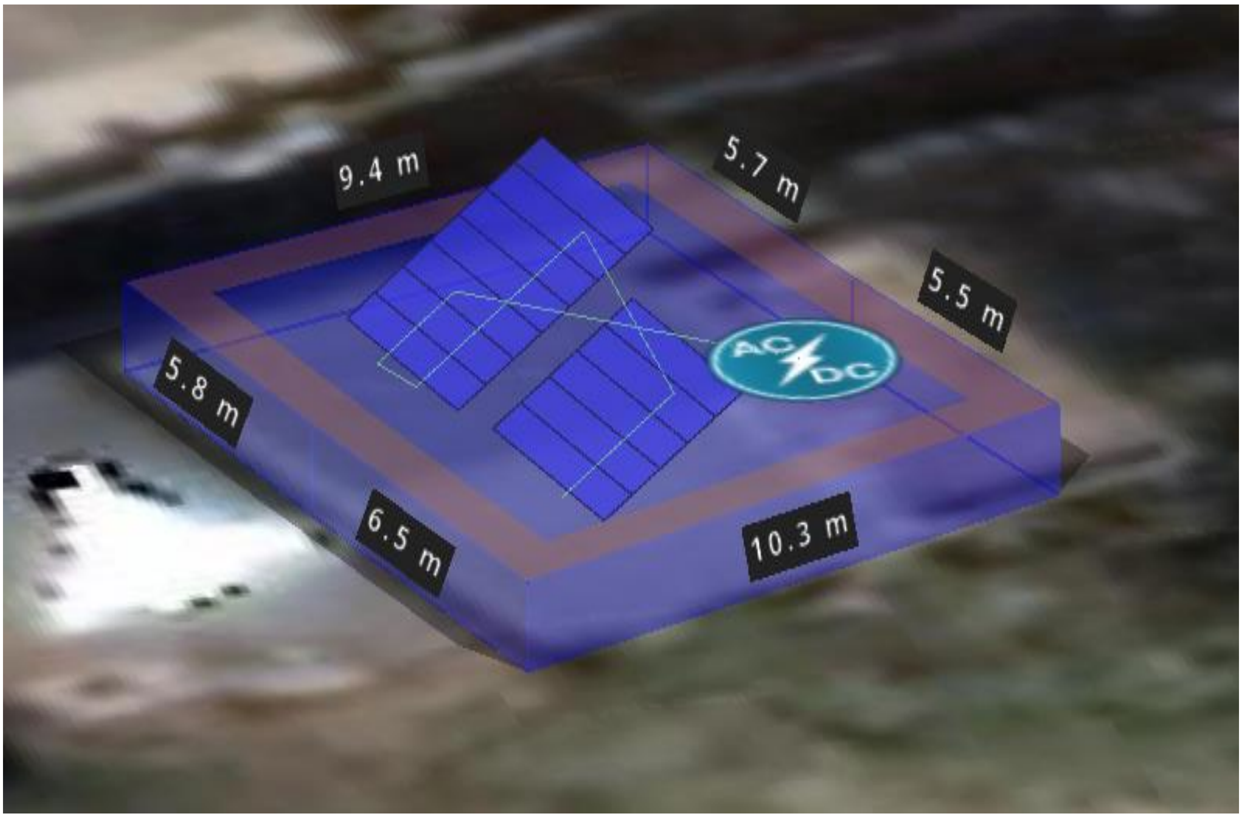

Figure 11: 3D design of 4kwp rooftop solar project

By Analysis we must determine tilt angle and Azimuth angle of Project site.

5.5.3 Required Materials

1.Solar Module- Trina320Wp

2.Inverter-4kWp

3.Fittings

4.Cable

5.Circuit Breaker

5.5.4 Generation Per Month Per Meter Square using PVSyst software

With this software we can assume that how much we will get energy from per meter square-hour. For example in January month we can get 135.2 kWh per Meter square.

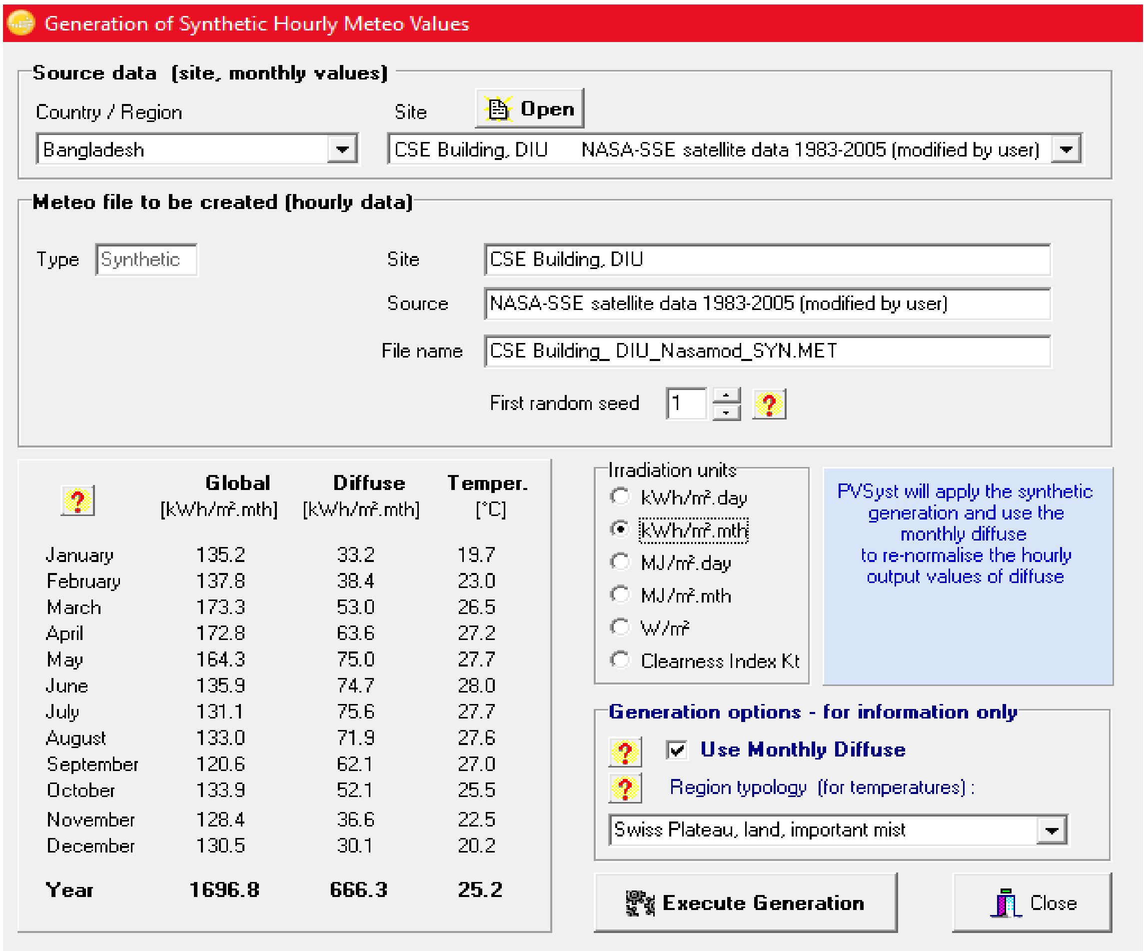

Figure 12: Generation Per Month Per Meter Square of Project site (CSE Building)

Annual generation data is given below of twenty years.

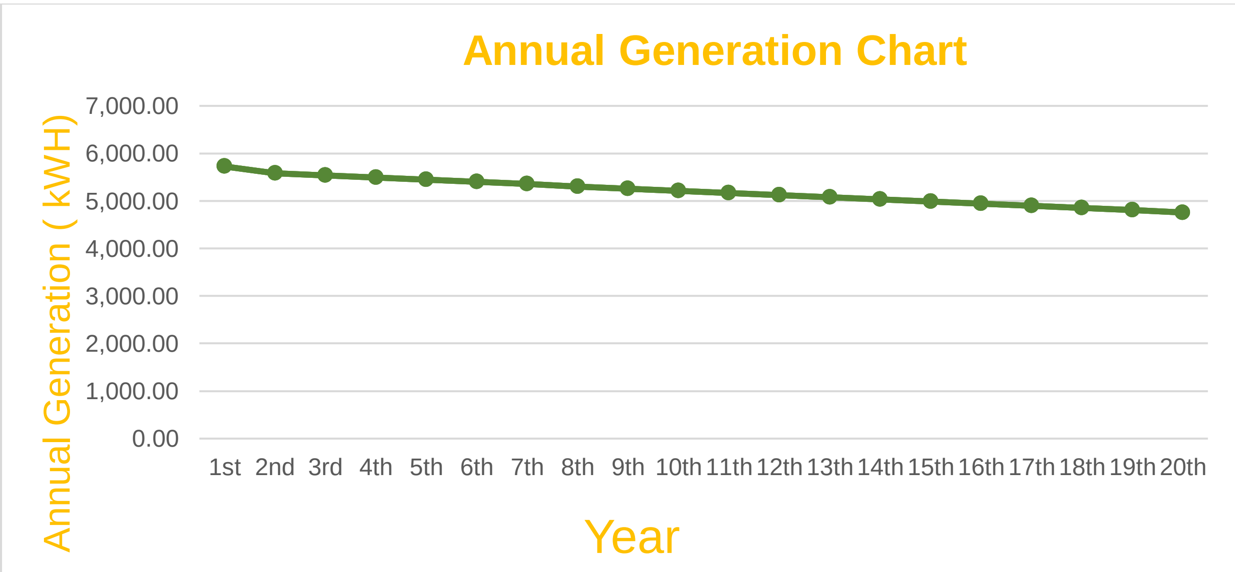

Figure 13: Annual generation chart of this 4kWp rooftop solar project

5.5.5 Financial Data Analysis

Financial data analysis includes project life time, capacity, plant efficiency, annual generation, and profit.

Table 12: Financial data analysis of 4kwp solar rooftop project

Year	capacity (kW)	Annual sunlight (Hour)	Expected Tariff (BDT)	Annual Panel efficiency	Plant efficiency	Annual Generation (kWH)	Annual Revenue (BDT)	Operation and maintenance cost (BDT)	Profit (BDT)
1st	4	1,789	7.57	100.00%	80.00%	5,724.80	43,336.74	0.00	43,336.74
2nd			7.57	97.50%		5,581.68	42,253.32	0.00	42,253.32
3rd			7.57	96.70%		5,535.88	41,906.62	0.00	41,906.62
4th			7.57	95.90%		5,490.08	41,559.93	0.00	41,559.93
5th			7.57	95.10%		5,444.28	41,213.24	0.00	41,213.24
6th			7.949	94.30%		5,398.49	42,909.87	0.00	42,909.87
7th			7.949	93.50%		5,352.69	42,545.84	0.00	42,545.84
8th			7.949	92.70%		5,306.89	42,181.81	0.00	42,181.81
9th			7.949	91.90%		5,261.09	41,817.78	0.00	41,817.78
10th			7.949	91.10%		5,215.29	41,453.75	0.00	41,453.75
11th			7.949	90.30%		5,169.49	41,089.73	0.00	41,089.73
12th			7.949	89.50%		5,123.70	40,725.70	0.00	40,725.70
13th			7.949	88.70%		5,077.90	40,361.67	0.00	40,361.67
14th			7.949	87.90%		5,032.10	39,997.64	0.00	39,997.64
15th			7.949	87.10%		4,986.30	39,633.61	0.00	39,633.61
16th			8.346	86.30%		4,940.50	41,233.06	0.00	41,233.06
17th			8.346	85.50%		4,894.70	40,850.83	0.00	40,850.83
18th			8.346	84.70%		4,848.91	40,468.60	0.00	40,468.60
19th			8.346	83.90%		4,803.11	40,086.37	0.00	40,086.37
20th			8.346	83.10%		4,757.31	39,704.14	0.00	39,704.14
Total 20 Years						**103,945.19**	**825,330.26**		**825,330.26**

Projected revenue from 4kWp Project in 20 years

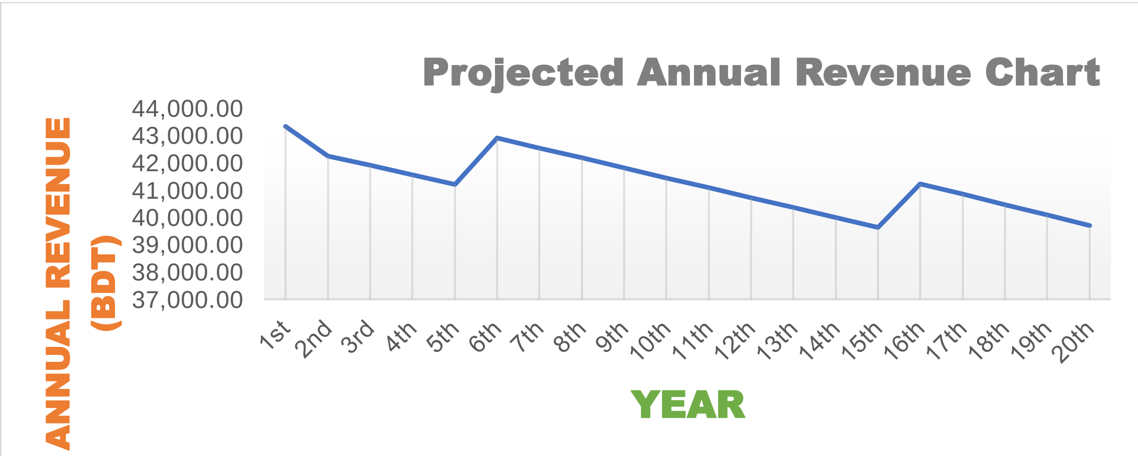

Figure 14: Projected annual revenue chart of 4kWp Project

Pay Back Period: Payback period for this 4kWp is only 6 years.

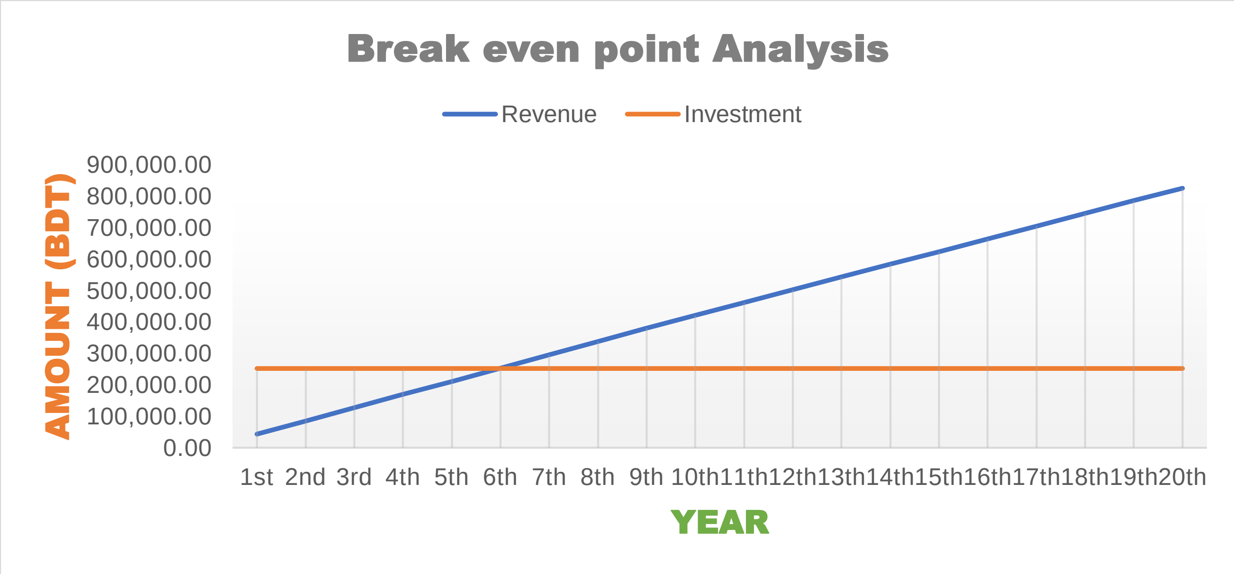

Figure 15: Break-even point or this 4kWp Rooftop solar project

5.5.6 Summary of this 4kWp Project

Table 13: Summary of 4kWp rooftop solar project

Projection	Unit	Amount
Generation Capacity	kW	4.00
Required Space (approx.)	Square feet	1,995.00
Project Life (extendable)	Years	20.00
Initial investment	BDT	252,000.00
Total Investment for 20 years	BDT	252,000.00
Project life total revenue	BDT	825,330.26
Net profit after 20 years (Project timeline)	BDT	573,330.26
Payback Period	Years	6.00

So, we can install mini on grid Solar PV System for light and fan Load. It will save energy from grid as well as will reduce CO_2 generation from National grid.

CHAPTER 6

CONCLUSION

6.1 Findings

Energy assessment of CSE building reveals that cooling load consumes 37% of total energy usage and desktop computer above 50% whereas other equipment consumed 4% only. Therefore, it is recommended to replace all desktop computer by laptop which will save around 52% of electricity and payback period almost 11years. Likewise, BDT 81,612 per year electricity bill could be reduced only by setting AC temperature to 24 degree centigrade.

Additionally, 4KWp solar PV System on respective building roof could be installed which could run small appliances load like Light, Fan. It will help us to reduce Uses of Electricity from Grid. It will save national demand as well as will reduce CO_2 emission.

By installing solar plant electricity generation from solar installation, we will get 5000 kwh per year in average. In total project lifetime 20 years plant will produce 103,945.19 kWh. Annual revenue from plant 825,330.26 in 20 years. This is total profit we can gain by installing rooftop solar plant.

Total investment for this project is only 252,000 BDT & payback period for this project 6 year only.

So, this solar project is a good solution for as well as value for money and for sustainable energy.

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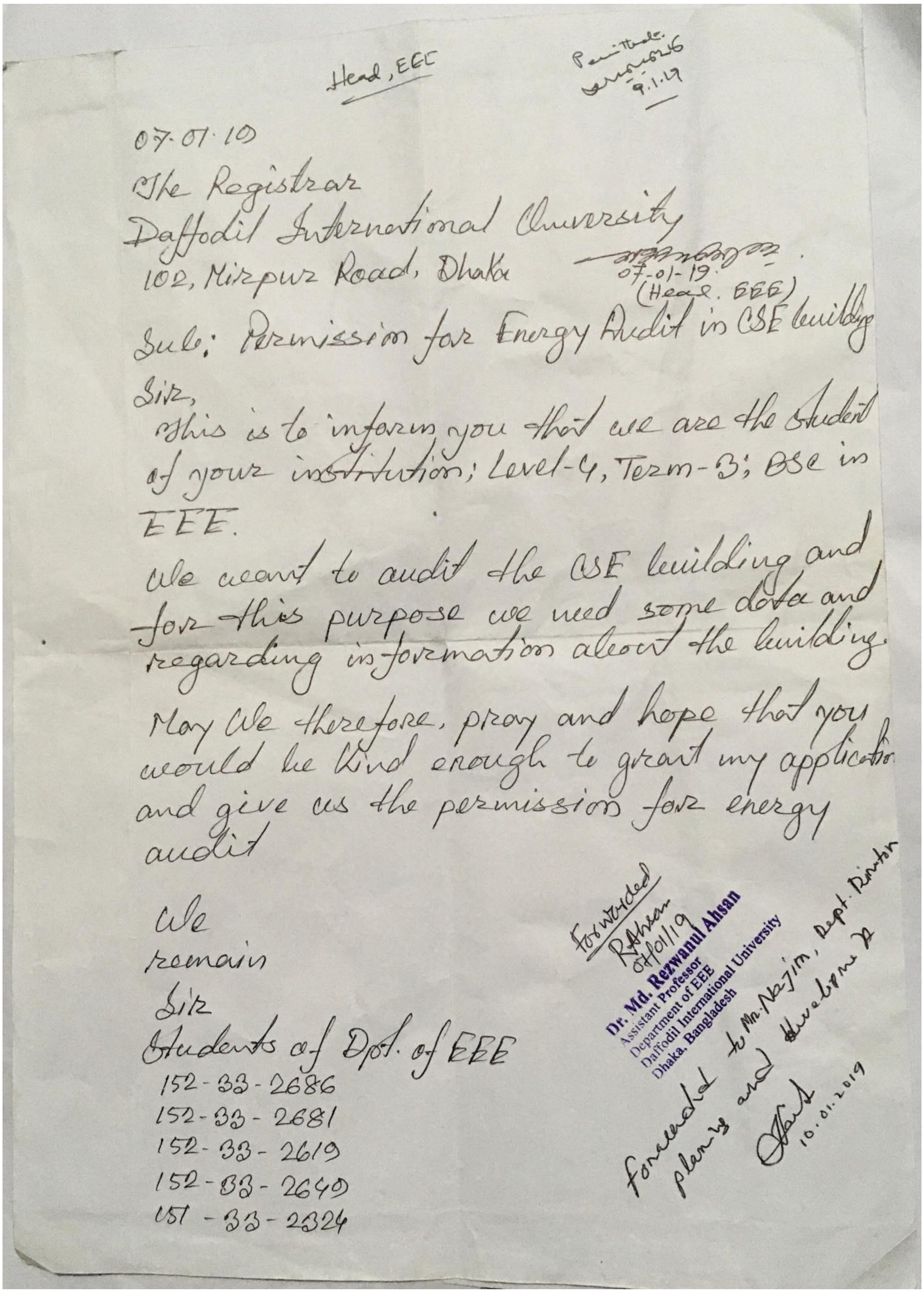
APPENDIX

Application for Energy Audit in CSE Building, DIU



Head, EEE

Permitted.
9.1.19

07.01.19

The Registrar
Daffodil International University
102, Mirpur Road, Dhaka

07-01-19
(Head. EEE)

Sub: Permission for Energy Audit in CSE building

Sir,
This is to inform you that we are the student of your institution; Level-4, Term-3; BSc in EEE.

We want to audit the CSE building and for this purpose we need some data and regarding information about the building.

May We therefore, pray and hope that you would be kind enough to grant my application and give us the permission for energy audit

We
remain
Sir
Students of Dpt. of EEE
152-33-2686
152-33-2681
152-33-2619
152-33-2649
151-33-2324

Forwarded
RAhsan
07/01/19
Dr. Md. Rezwanul Ahsan
Assistant Professor
Department of EEE
Daffodil International University
Dhaka, Bangladesh

Forwarded to Mr. Nazim, Dept. Director planning and development
10.01.2019