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Integrated Energy Management of Residential Halls at University of Dhaka by Using Energy Efficient Appliances and Solar PV System

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ABSTRACT

This paper analyses the electrical energy consumption of two residential halls at University of Dhaka and design the best approach to diminish the electrical energy consumption and reduce the carbon emission and achieve efficient energy utilization in the halls. Fazlul Haque Muslim Hall and Dr. Mohammad Sahidullah Hall were selected for a detailed study of electricity consumption. Series of data were taken to estimate the electrical energy consumption and the electrical energy losses across different loads. Afterwards with the results of electrical usage, an energy stability was made by considering the energy efficient electrical appliances along with a solar photovoltaic system to reduce the electrical energy wastage and reduce the carbon emission to maintain the environment clean. Overall energy losses can be minimized up to 40% and 41% at Fazlul Haque Muslim Hall and Dr. Mohammad Sahidullah Hall respectively with new energy efficient devices. A total of 43% and 44% energy consumption can be reduced at Fazlul Haque Muslim Hall and Dr. Mohammad Sahidullah Hall with the proposed new energy management system that implies to utilize solar energy using solar photovoltaic. The emission of carbon reduction estimate was about 302 tons and 290 tons of CO_2 at Fazlul Haque Muslim Hall and Dr. Mohammad Sahidullah Hall respectively. The payback period of the investment to replace the electrical appliances with energy efficient appliances and to install a solar photovoltaic system is 2.45 years.

***Keywords*—** Energy Audit, Solar Photovoltaic, Carbon Emission

I. INTRODUCTION

Electrical energy is the most expedient one between various forms of energy, which is the driving force behind all types of human activities, growths and researches in other areas of technologies. According to Bangladesh Power Development Board, the installed power generation capacity is about 16982 MW, derated power generation capacity is 16344 MW out of which 440 MW is generated by coal-fired power plants, 9469 MW from gas power plants, 3595 MW from HFO, 1666 MW from HSD, 230 MW from hydro power stations and 660 MW are imported in 2018 [1]. Nevertheless of this, Bangladesh still agonizes from main shortage of electricity generation to fulfil the daily demand and the peak demand would be about 17,304 MW in FY2020 and 25,199 MW in 2025 [2]. Solar, biomass & wind are the protruding candidate among the accessible renewable energy sources in Bangladesh. Hypothetically, Bangladesh gets 69,751 TWh energy every year which is 3000 times higher than the conservative electricity generation [3]. In Bangladesh Per annum, solar radiation has an average power density of 100-300 W/m^2 which can generate 100 MW electricity with an area of 3-10 km^2 with a panel of 10% efficiency [4]. In a year with 6.8% (10,000 km^2) of the land of Bangladesh, per capita 3000 kWh electricity mandate can be attained [5]. The government of Bangladesh acmes the requirement of installing rooftop solar PV system due to the scarcity of land. Researcher have found that 1000 MW of solar PV electricity with 75 W capacity of the solar module can be produced by the total accessible sunny rooftops area in Dhaka city which is 10.554 km^2. [6] In Bangladesh only 1.7% suitable land area is used for producing electricity from solar PV as the accessible presence of grid connection [7]. Researcher found that solar PV operated in a grid-connected mode with 10% efficiency of solar PV system and 200 W/m^2 annual typical value of solar radiation can produce about 50,174 MW of grid electricity in Bangladesh. [8] Furthermore prevailing engendering power are also wasted both in industrial site as well as household by using low efficiency but high power rating equipment. Energy Audit is measured to be one of the vital and obligatory components to save energy bills and to preserve national energy possessions of a country like Bangladesh which is greatly depend on upon natural possessions for power generation. [9]

A. Energy Management [10]

Energy Management is well defined by the approach of modifying and optimizing energy, using systems and techniques so as to diminish energy necessities per unit of output while holding relentless or sinking total costs of making the output from these systems.

The determinations of energy management are stated below:

- Improving energy efficiency and plummeting energy use, thereby plummeting costs

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- Diminish greenhouse gas emissions and advance air quality
- Emerging and keeping effective monitoring, reporting and controlling approach for astute energy practice.
- To diminish energy costs, environmental possessions, and unwanted without disturbing production and quality.
- Taking new and better techniques to growth returns from energy funds through study and development.

B. Energy Audit *[10]*

An energy audit is defined by categorizing energy losses, measuring them, assessing conservation potential, developing technological options for conservation and assessing techno economics for the procedures recommended.

- To contribute a progressive alignment to the energy cost reduction, preemptive maintenance.
- To possess attention on variations that arises in the energy costs, availability, and reliability of supply of energy.
- To decide on the suitable energy mix, classify energy conservation technologies and retrofit for energy preservation equipment.

1. Electrical Equipment Audit

Electrical apparatus audit is defined by auditing any equipment powered by the electricity or electrical appliances It is significant to audit the electrical apparatus like lights, fan includes ceiling fan and stand fan, computer, air conditioner, refrigerator, and elevators are prominently connected to the electrical energy consumption and used in any type of building such as- in residential, commercials and in industries. Number of equipment, wattage ratings and operation time are the key parameter used in this audit.

2. Lighting Audit

In Bangladesh more than 30% of the total electrical energy is consumed by lighting system with desired level of illumination. [11] About 25% to 35% of the total generated power in the world is consumed by lighting system where 15% and 30% of electrical energy is consumed by lighting system in residential buildings and commercial buildings respectively. [12] At the present time, for getting equal luminous level Fluorescent Lamps (FLs) and Compact Fluorescent Lamp (CFLs) is preferred to Incandescent Lamps due to three to four times higher efficiency and two to three times higher lifetime [12]. FLs and CFLs are discharged lamps and they require ballast which produces high initial voltage across lamp tube for essential lamp ignition and to limit the lamp current [13]. Magnetic ballast bring out extra heat losses across the ballast [13] whereas Electronic ballast is much more effective than Magnetic ballast although lifetime of Electronic ballast is lower than the Magnetic ballast [14]. Usage of lighting energy can be diminished by 75% to 90% likened to the conventional practice [15]. In Bangladesh, frequently Incandescent and Fluorescent lights were used [16]. Besides with High Intensity discharge lamps (HIDs) such as, Low Pressure Sodium Lamps (LPSLs), High Pressure Sodium lamps (HPSL), Halogen Lamps (HL) and energy efficient bulbs known as Light emitting diode (LED) which is willingly available in markets, and this energy efficient bulb can diminish energy consumption by 50% [17,18]. As a developing country Bangladesh needs to look towards energy efficient equipment due to many aspects [19].

The aspects are on the following:

1. Higher expenditure in erecting new power plants.
2. Progressive population increases the power demand.
3. Absence of capital for the financing in alternate options.
4. Huge impact of carbon emissions on environment due to increased energy consumption [19]

Thus, substituting towards energy saving light technologies can retrieve substantial quantity of energy [20].

3. Higher Rating Electrical Appliance Audit

a. Air Conditioner

Cooling capacity, Air flow, Noise, Dehumidification, Power consumption, EER & SEER are the key factors for selecting suitable air conditioners. [21]

- To attain a certain room temperature and humidity the heat load in a room that has to be removed is well-defined by cooling capacity. Cooling capacity is expressed in terms of BTU's/hour, where one ton of cooling capacity equivalents to 12,000 BTU's/hour. Cooling capacity increases with the higher rate of BTU/hour.
- The typical design parameter is to set 24°C and 55% relative humidity which are most prosperous to human body [22].
- The lesser the power consumption, the more is the efficiency of the air conditioner. [21]
- EER (energy efficiency ratio) is the ratio of rated cooling capacity and input power, the higher the value of EER, the more efficient the air conditioner is. [21]
- SEER (Seasonal Energy Efficiency Ratio) is the ratio of the total cooling capability of equipment that is delivered over the whole season (Btu) and the total energy in Watt-hours it will consume. SEER will be greater in efficient equipment. [21]

b. Ceiling Fan

Fan size, Blade angle, CFM, Types of motor used in ceiling fan are the key aspects for selecting energy efficient ceiling fan.

- Fan size is indicated by the diameter of the circle that revolving blades are made. Comfort level of a room is directly related to the room size with the

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fan size. Different fan size of 24-42", 44-50", 52-60", 62" are more suitable for 80 Sq.ft, 100-150 Sq.ft, 150-300 Sq.ft, and larger than 300 Sq.ft respectively. [23]

- Angle between the blades should be of 12-14° otherwise it will be flat and reduce the air flow. [23]
- The air flow in cubic feet per minute is defined by CFM, higher CFM diminish the cooling cost which should be at least 6000-7000 CFM. [23]
- Almost 50% power is consumed by a ceiling fan using BLDC (Brush Less DC) motor than that of a fan using split phase induction motor. [24]
- Power consumption can be reduced from 70-75W to 45-50W by achieving higher speed. [24]
- 70 TWh electrical energy will save and can diminish 25 million tons of emission in a year by utilizing energy efficient practice in all fans sold by 2020 worldwide and connect them properly. [25].

c. Computer Monitor

- Cathode Ray Tube (CRT) monitors consume around 100W where LCD monitors consume less power than CRT [26].
- LED monitors are more effective than CRT and LCD as it consume lesser power. [26]

Moreover to this, power can save by taking the following steps:

- By connecting automated sensor based fans.
- By setting timers in air conditioner.
- By setting the monitors in optimum brightness level which is about 15-30 percent for each LCD monitors can efficiently diminish power. [27]

II. METHODOLOGY

The energy consumed in Fazlul Haque Muslim Hall, University of Dhaka is delivered by only one energy source and that is electricity comes from local utility suppliers named DPDC (Dhaka Power Distribution Company). Numbers of the light are counted through visual inspection within each zone to help classify the Lighting Power Densities (LPD).

In these hall rooms a lot of energy was consumed by the different types of electronic devices.

At the first step the electrical load was measured and the data was calculated. The calculation was divided in two slabs peak hour energy consumption and off-peak hour energy consumption. The energy consumption in different areas of the hall was calculated. Then the top energy consuming devices was selected and was considered the energy efficient devices and the overall calculation was done again. By comparing the two calculations energy savings was calculated and corresponding reduction of carbon emission was also calculated. A certain portion of electrical energy was proposed with solar photovoltaic system with the proper sizing and installation cost.

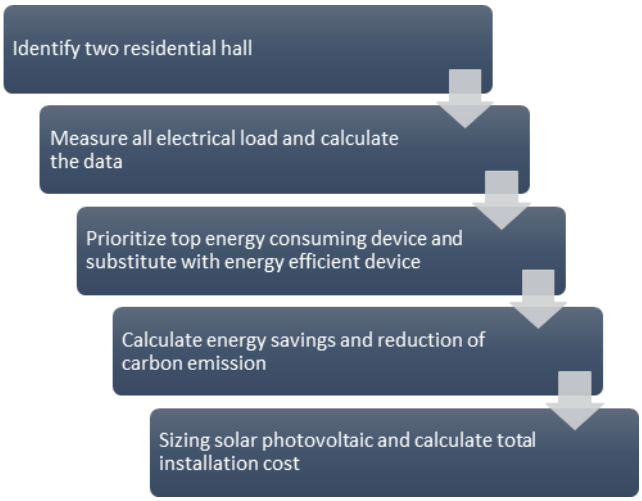

Fig 1 Flow chart of methodology

III. EXPERIMENTAL WORK

A. Electrical Load Calculation of Fazlul Haque Muslim Hall, University of Dhaka

Table: 1 Lists of electrical equipment

Electrical Equipment	Rating(W)
Table Fan	40
Tube Light	55
Ceiling Fan	105
Table Lamp	60
Desktop Computer	150
Laptop	50
Mobile Charger	4
52''Led Television	70
Refrigerator	450
Electric Iron	1000
Air Conditioner	3517 w or 1 ton or 12000 BTU/hr.
Electric Trimmer	300

Table 2 Total Energy consumption of Fazlul Haq Muslim Hall, University of Dhaka

Building Name	Daily Energy Demand (kWh)	Peak Energy Consumption (kWh)	Off-Peak Energy consumption (kWh)
South	1413.744	485.4	928.344

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Building			
Main Building	1449.244	508.18	941.064
Mosque	13.755		13.755
Provost Office	44.66		44.66
Reading Room	58.77	16.05	42.72
Canteen	8.12	3.045	5.075
Dining Hall	26.1	11.07	15.03
Television Room	13.36	8.35	5.01
Saloon	7.08	2.78	4.3
Iron room	35.625	11.875	23.75
Total	**3070.458**	**1046.75**	**2023.708**

All kinds of electrical data was analyzed and numerous types of energy efficiency measures were recommended. The load of living rooms were analyzed and some drawbacks were found. The unit of electricity is consumed by the students of the hall is a vast amount per day.

According to the existing tariff fixed by government's power Distribution Company in Dhaka, this two hall has fallen into the F category: Medium voltage, General Purposes (11kv). From the tariff plan, in peak hour the rate of per unit i.e. per kWh is 10.06 BDT and in off-peak hour per unit rate is 7.25 BDT.

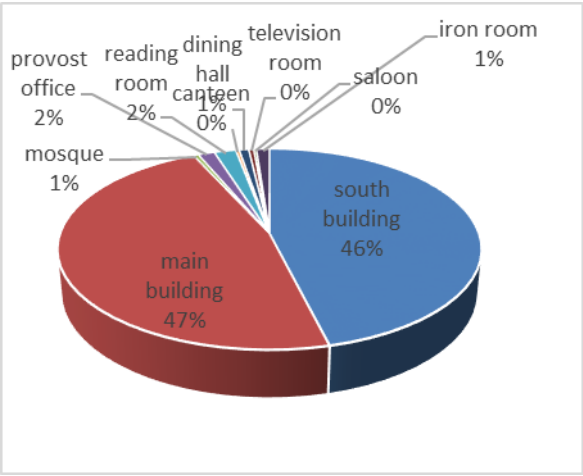

Fig: 2 Energy consumption in different location in the hall

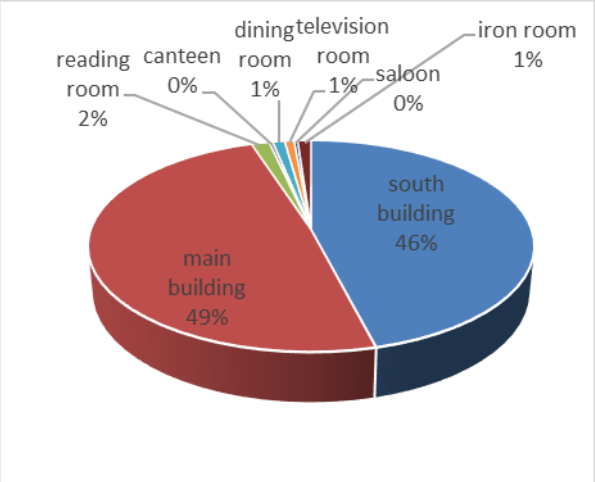

Fig 3 Energy consumption in peak hour in different location in the hall

Table 3 Cost of electricity bill

Peak-hour (7-12pm) bill (BDT)	**Off-peak hour bill (BDT)**	**Total daily electricity bill (BDT)**	**Monthly electricity bill (BDT)**	**Annually electricity bill (BDT)**
10531	14672	25203	756090	9073080

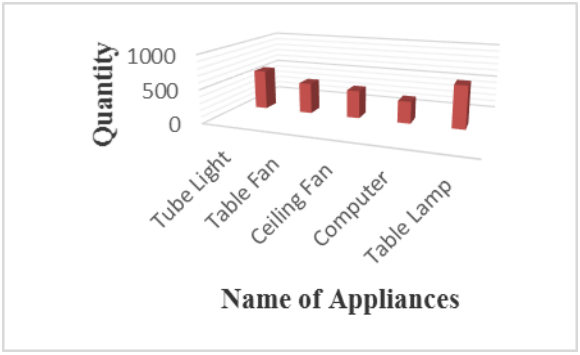

Fig 4 Top Energy Consuming Appliances

B. Electrical Load Calculation of Fazlul Haque Muslim Hall by considering energy efficient electrical appliances

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Table 4 Rating of energy efficient electrical equipment

Electrical Equipment	Rating(W)
Table Fan	15
Tube Light	39
Ceiling Fan	40
Table Lamp	48
Desktop Computer	70
Laptop	50
Mobile Charger	4
52'Led Television	70
Refrigerator	450
Electric Iron	1000
Air Conditioner	3517 w or 1 ton or 12000 BTU/hr
Electric Trimmer	300

Table 5 Total Energy consumption of Fazlul Haq Muslim Hall using energy efficient appliances

Building Name	Daily Energy Demand (kwh)	Peak Energy Consumption (kwh)	Off-Peak Energy consumption (kwh)
South Building	858.56	304.88	553.68
Main Building	842.972	313.362	529.61
Mosque	7.28		7.28
Provost Office	32.168		32.168
Reading Room	30.51	8.475	22.035
Canteen	4.104	1.539	2.565
Dining Hall	17.184	7.188	9.996
Television	6.88	4.3	2.58
Room			
Saloon	4.17	1.81	2.36
Iron room	32.955	10.985	21.97
Total	**1836.783**	**652.539**	**1184.244**

Table 6 Top 5 major devices that save most electrical energy

Appliance Name	Energy saving appliance name	Total Quantity	Consumption by a single appliance (watt)	Energy saving by a single appliance (watt)	Daily consumption (kwh)	Saving energy (kwh)
4 feet tube light	T-6 or T-8	590	55	39	475.53	335.01
Table fan	Table fan	456	40	15	304	114
56" ceiling fan	Energy star rated ceiling fan	411	105	40	726.075	273.6
Desktop	Desktop with LED monitor	325	150	70	728.55	339.99
Table lamp	Table lamp	626	60	48	242.52	194.016

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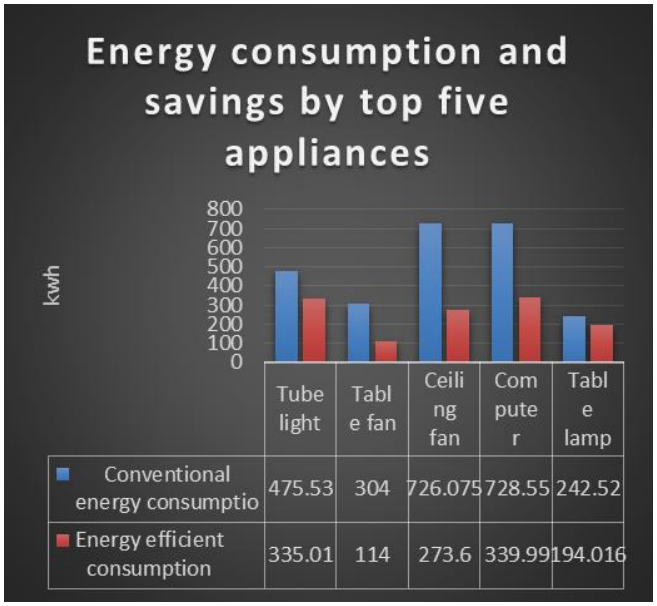

Fig 5 Comparison of conventional energy consumption and energy efficient consumption

Table 7 Cost of electricity bill using energy efficient appliance

Peak-hour (7-12pm) bill (BDT)	Off-peak hour bill (BDT)	Total daily electricity bill (BDT)	Monthly electricity bill	Annually electricity bill (BDT)
6565	8586	15151	454530	5530115

The generation of electricity is typically based on the burning and consumption of various fossil fuels in Bangladesh. To generate 1 MWh of electricity 0.67 tons of CO_2 is emitted to the environment [28].

Table 8 Comparison of electricity unit and electrical bill

Parameter	Conventional electricity consumption	Energy efficient electricity consumption	Savings
Total electricity unit annually (MWh)	1121	671	450
Total bill(BDT) annually	9073080	5530115	3542965

C. Electrical Load Calculation of Dr. Muhammad Sahidullah Hall by considering conventional electrical appliances

Table 9 Total Energy consumption of Dr. Muhammad Sahidullah Hall, University of Dhaka

Building Name	Daily Energy Demand (kWh)	Peak Energy Demand (kWh)	Off-Peak Demand (kWh)
Main Building	1584.5	534.93	1049.07
Building-1	459.28	153.45	305.83
Building-2	660.094	172.535	487.559
Mosque	13.755		13.755
Provost Office	44.66		44.66
Reading Room	58.77	16.05	42.72
Canteen	8.12	3.045	5.075
Dining Hall	26.1	11.07	15.03
Television Room	13.86	8.35	5.01
Saloon	7.08	2.78	4.3
Iron Room	35.625	11.875	23.75

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Total	**2911.85**	**915.05**	**1996.76**

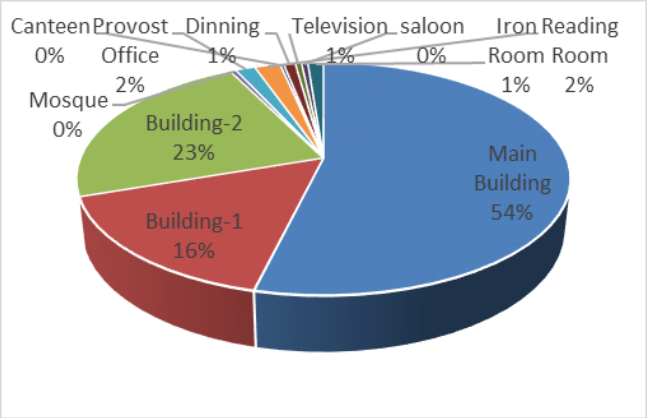

Fig 6 Energy consumption in different location in the hall

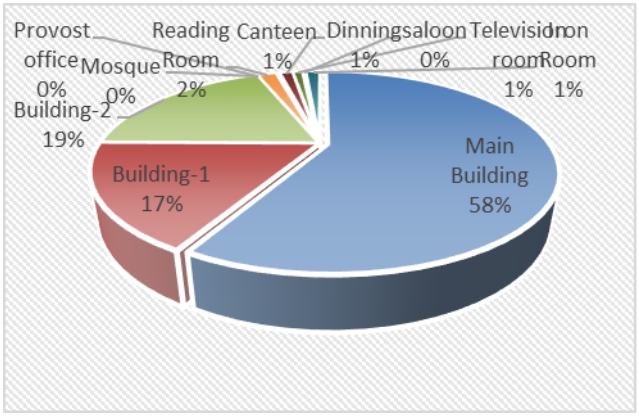

Fig 7 Energy consumption in peak hour in different location in the hall

Table 10 Cost of electricity bill

Peak hour (7-12pm) bill (BDT)	Off-peak hour bill (BDT)	Total daily electricity bill (BDT)	Monthly electricity bill (BDT)	Annually electricity bill (BDT)
9206	14477	23683	710490	8644295

D. Electrical Load Calculation of Dr. Muhammad Sahidullah Hall by considering energy efficient electrical appliances

Table 10 Total Energy consumption of Dr. Mohammad Sahidullah Hall considering energy efficient electrical appliances

Building Name	Daily Energy Demand (kWh)	Peak Energy Consumption (kWh)	Off-Peak Energy consumption (kWh)
Main Building	929	328.33	600.67
Building-1	272.5	94.71	177.8
Building-2	387	136	251
Mosque	7.28		7.28
Provost Office	32.168		32.168
Reading Room	30.51	8.475	22.035
Canteen	4.104	1.539	2.565
Dining Hall	17.184	7.188	9.996
Television Room	6.88	4.3	2.58
Saloon	4.17	1.81	2.36
Iron room	32.955	10.985	21.97
Total	**1723.8**	**593.34**	**1130.5**

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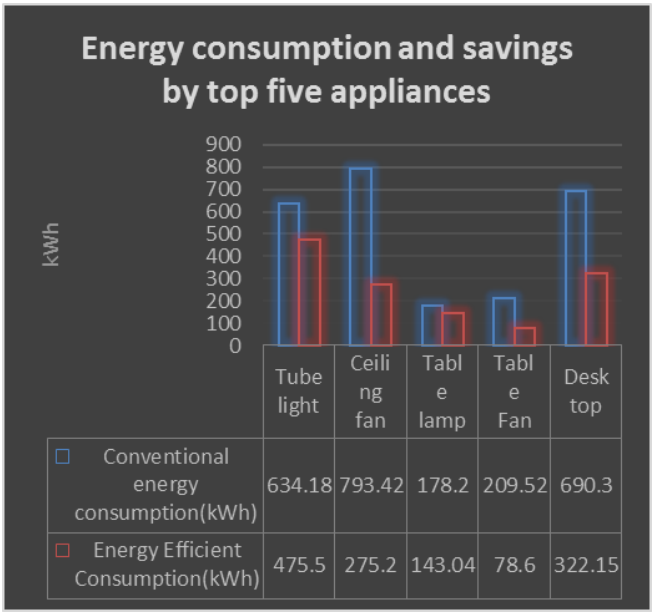

Fig 8 Comparison of conventional energy consumption and energy efficient consumption.

Table 11 Cost of electricity bill using energy efficient appliance

Peak-hour (7-12pm) bill (BDT)	Off-peak hour bill (BDT)	Total daily electricity bill (BDT)	Monthly electricity bill	Annually electricity bill (BDT)
5969	8197	14166	424980	5170590

Table 12 Comparison of electricity unit and electrical bill and carbon emission

Parameter	Conventional electricity consumption	Energy efficient electricity consumption	Savings
Total electricity unit annually(MWh)	1063	630	433
Total bill (BDT) annually	8644295	5170590	3473705
Carbon emission annually(tons of CO_2)	713	423	290

E. Sizing of Solar photovoltaic system for Mosque, Reading room, Canteen

Among the total electricity of Fazlul Haque Muslim Hall, University of Dhaka and Dr. Mohammad Sahidullah Hall, University of Dhaka about 6% of electricity is consumed by mosque, canteen, and reading room with the conventional electrical equipment with the conventional power source which leads enormous amount of electricity wastage and GHG emission. If the conventional electrical equipment and conventional power source is switched by energy rating electrical equipment and solar photovoltaic then it would be more economical and environmentally friendly.

Table 13 AC load calculation for reading room

Load	Daily use hour	Wattage (W)	Watt-hour/day	Inverter efficiency	AC load expressed as dc (watt hour/days)	Total AC load expressed as dc(watt-hour/days)
T-6 or T-8	18	39	702	90 %	780	25*780=19500
Energy rated ceiling fan	18	40	720	90 %	800	18*800=14400

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Total						33900

Total electricity demand= 33900 watt-hour/day

1. Array sizing:
Required peak watt = 33900/4=8475 Wp
Battery efficiency = 80%
Peak watt = 8475/0.8=10593.75
Consider 20% design margin = 10593.75*1.2=12713 Wp
No of PV module =12713/260= 48.89≈49 modules

2. Battery sizing:
Battery capacity= load in watt-hour per day * days of autonomy / maximum percentage
=33900*3/0.8=127125
Nominal Battery voltage: 12v
AH of Battery = 127125/12= 10593.75 AH
No. of Battery =10593.75/200= 52.9≈53

3. Charge controller:
Charge controller rating 12V, 10A
Each modules is 260 Wp; Voc=37.40 V, Isc=9.27 A
No.of charge controller required= No.of modules/2=49/2=25

4. Inverter sizing:
Peak Ac load=79 w
Increase the size by 25% for safety
Peak AC load=79*1.25=98.75 w=0.098 Kw

5. Total system cost:
Module cost= Wp of 49 module* cost per Wp=49*260*34=433160 BDT
Charge controller cost= 25*700=17500 BDT
Battery cost= 53*19500=1033500 BDT
Inverter cost= 10000*0.098=980 BDT
Miscellaneous cost= 20000 BDT
Total cost= 433160+17500+1033500+980+20000=1505140 BDT.

Table 14 Summary of Solar photovoltaic sizing of canteen, reading room, and mosque

	Array Sizing	**Charge controller sizing**	**Battery sizing**	**Inverter sizing (KW)**	**Total System cost (BDT)**
Canteen	Rating:230Wp, Voc=36.9V Isc=8.32A No of PV module=8	Rating:12V,10A No of charge controller=4	Rating:12V,100A No of battery =15	0.098	261340
Reading room	Rating:260Wp, Voc=37.40v Isc=9.27 No of PV module=49	Rating:12V,10A No.of Charge controller=25	Rating: 12V, 200 AH No of Battery=53	0.098	1505140
Mosque	Rating:260Wp, Voc=37.40v Isc=9.27 No of PV module=12	Rating:12V,10A No of charge controller=6	Rating:12V,200AH No of Battery=13	0.236	389260

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IV. RESULT & ANALYSIS

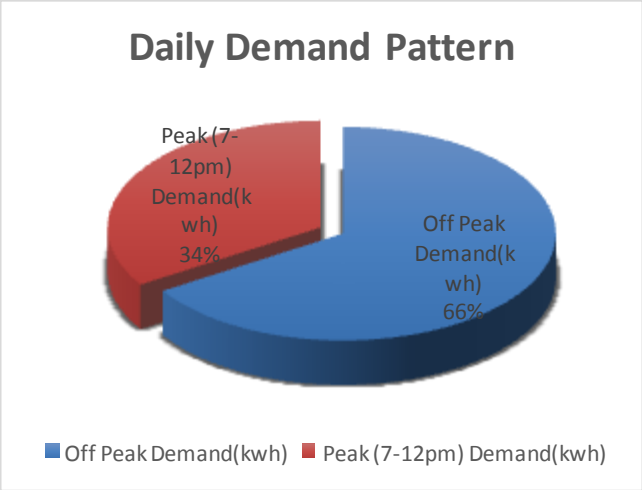

Fig 9 Daily demand pattern in the Fazlul Haque Muslim Hall

In a day Fazlul Haque Muslim Hall University of Dhaka consume the electrical energy =3070.458 kWh

So annually this hall consumes about = 1120.72 MWh

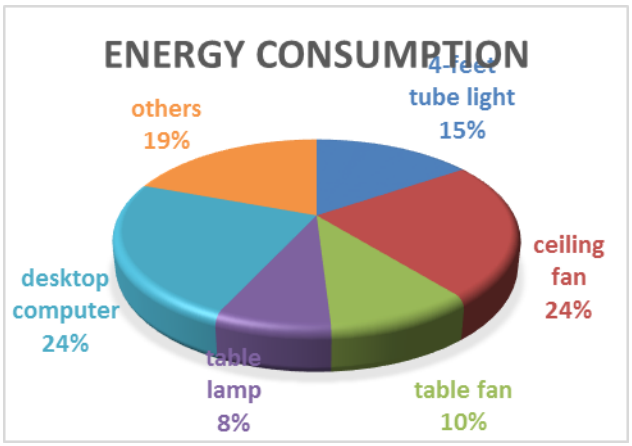

Fig 10 Top energy consumption for different load Fazlul Haque Muslim Hall

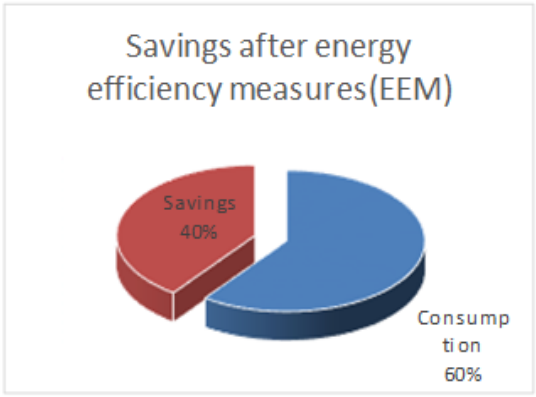

Fig 11 Savings After energy efficiency measures (EEM) Fazlul Haque Muslim Hall

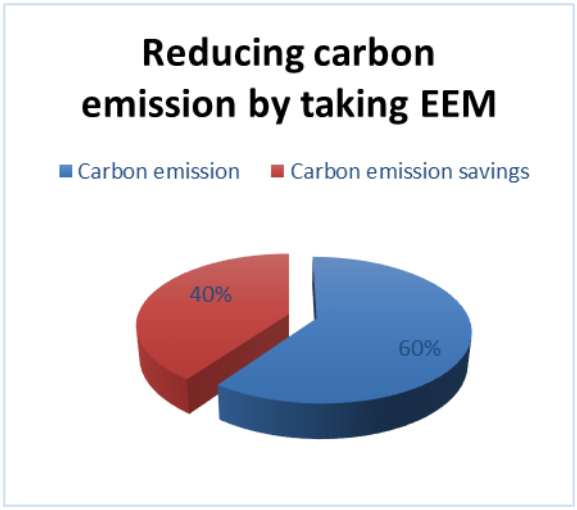

Fig 12 Reduction of carbon emission Fazlul Haque Muslim Hall

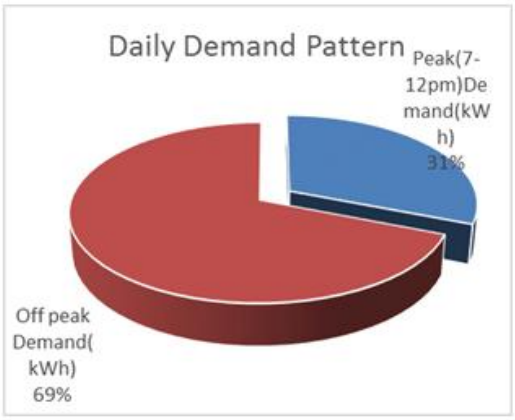

Fig 13 Daily demand pattern in the hall Dr. Mohammad Sahidullah Hall, University of Dhaka

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In a day Dr. Mohammad Sahidullah Hall, University of Dhaka consume the electrical energy =2911.85 kWh

So annually this hall consumes about = 1063 MWh

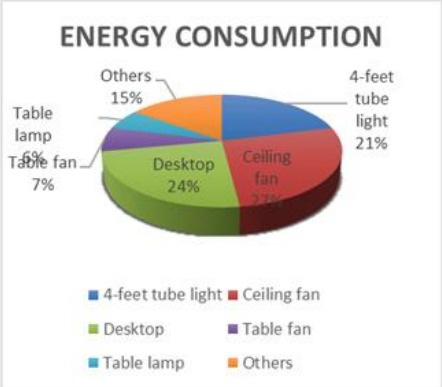

Fig 14 Top energy consumption for different load Dr. Mohammad Sahidullah Hall, University of Dhaka

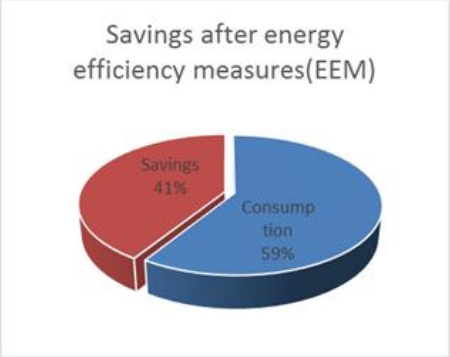

Fig 15 Savings after efficiency measures (EEM) at Dr. Mohammad Sahidullah Hall, University of Dhaka

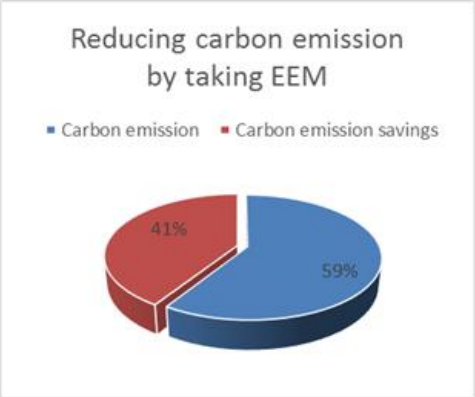

Fig 16 Reduction of carbon emission Dr. Mohammad Sahidullah Hall, University of Dhaka

The electrical energy consumption pattern of the hall was analyzed and noticed some significant key factor. The Key factors are given below:

1. Lack of suitable ventilation system which consumes more electrical energy.
2. Higher rating of electrical equipment.
3. Absence of proper power system protection.
4. Unconsciousness of students about energy savings makes waste of a vast amount of electrical energy.

In Fazlul Haque Muslim Hall, University of Dhaka the most five energy consuming appliances are already indicated if we consider these five appliances by energy efficient appliances then we can save almost 40% of our valuable electrical energy and we'll save a big amount of 450MWh of total electricity annually and annually savings of carbon emission is 302 ton of CO_2.

In Dr. Mohammad Sahidullah Hall, University of Dhaka, the most five energy consuming appliances are previously indicated if we switch these five appliances by energy efficient appliances then we can save almost 41% of our valuable electrical energy and we'll save a big amount of 433 MWh of total electricity annually and annually savings of carbon emission is 290 ton of CO_2.

A solar photovoltaic system was designed for reading room, canteen, and mosque for both the hall, all these three have consumed 3% of total electricity of the entire hall, if the design is executed practically then it will save 3% of electricity for each hall which is (92+87=179) kWh electricity per day and reduce 0.12 ton of carbon emission per day.

Table 15 Overall fieldwork and prediction at a glance

	Fazlul Haque Muslim Hall	**Dr. Mohammad Sahidullah Hall**
Daily Peak electricity energy consumption (kWh)	1046.75	915.05
Daily Off-peak electrical energy consumption (kWh)	2023.708	1996.76
Daily electrical energy	3070.458	2911.85

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consumption (kWh)		
Annual electrical energy consumption (MWh)	1121	1063
Annual electricity bill (BDT)	9073080	8644295
Annually energy efficient electricity consumption (MWh)	671	630
Annually savings of total electricity (MWh)	450	433
Energy savings percentage	40%	41%
Annually energy efficient electricity bill (BDT)	5530115	5170590
Annually savings of total electricity bill(BDT)	3542965	3473705
Annually carbon emission (tons of CO_2), Conventional electricity consumption	752	713
Annually carbon emission (tons of CO_2), energy efficient electricity consumption (ton)	450	423
Annually savings of carbon emission (ton)	302	290
Reduction rate	40%	41%

V. PAYBACK PERIOD

The payback period is the amount of time that is estimated before an investment will be refunded in the form of income. Payback period means the period of time that a project needs to recover the money financed in it. The payback period of a project is stated in years and is computed using the following formula:

Payback Period= Investment necessary for a project / Net yearly cash inflow

If the payback period of a project calculated by the above formula is shorter than or equal to the management's maximum desired payback period, the project is accepted otherwise it is banned.

Each energy efficient small fan price is 3000 BDT, T-6 light price is 500 BDT, ceiling fan price is 3000 BDT, LED monitor price is 7000 BDT, and table lamp price is 300 BDT (approximately).

Table 16 Energy Efficient appliances cost in Fazlul Haque Muslim Hall

Energy Efficient Appliances	No.of appliances	Per Unit Appliances Cost(Approximately)	Total Appliances Cost(BDT)
T-6 light	590	500	295000
Ceiling Fan	411	3000	1233000
LED Monitor	325	7000	2275000
Table Fan	456	3000	1368000
Table Lamp	626	300	187800
Total	**5358800**		

Table 17 Energy Efficient appliances cost in Dr.Mohammad Sahidullah Hall

Energy Efficient Appliances	No. of appliances	Per Unit Appliances Cost (Approximately)	Total Appliances Cost(BDT)
T-6 light	752	500	376000
Ceiling Fan	394	3000	1182000
LED Monitor	308	7000	2156000
Table Fan	291	3000	873000

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Table Lamp	596	300	178800
Total			**4765800**

Solar PV installation price in canteen, reading room and Mosque is 261340 BDT, 1505140 BDT, and 389260 BDT respectively. Total= 2155740 BDT, for two hall total cost is = 2155740*2=4311480 BDT.

Total cost = 5358800+4765800+4311480= 14436080 BDT

According to refinance scheme of Bangladesh Bank, the interest rate is 9%, if the preliminary amount of investment is borrowed from the bank for three years.

The interest of this 14436080 will be =1299247.2 BDT (annually), for three years= 3897742 BDT

The Total amount that have to be paid is =14436080+3897742= 18333822 BDT

Annually savings of total electricity bill for Fazlul Haque Muslim Hall is= 3542965 BDT

Annually savings of total electricity bill for Dr.Mohammad Shahidullah Hall= 3473705 BDT

Annually savings of total electricity bill for the canteen of two hall is= 49222 BDT

Annually savings of total electricity bill for reading room of the two hall is= 343964 BDT

Annually savings of total electricity bill for mosque of the two hall is= 72799 BDT

Initial cash flow or the savings for a year is =3542965+3473705+49222+343964+72799=7482655 BDT

So, Payback period= 18333822 BDT / 7482655 BDT = 2.45 years.

VI. CONCLUSION

The electrical equipment of the two halls were found very high rating which has extra consumption of electricity, beside awareness is one of the reason for wastage of huge electricity. Moreover the savings not only measures in terms of money but also increase the penetration rate of electricity. In the hall there is sufficient potential of sun radiation but shortage of place to install solar photovoltaic system for the entire hall electricity consumption. For this purpose if we take a certain percentage of electricity from the solar PV system along with switching the high electricity consuming equipment by energy star rated equipment then it would diminish the wastage of electricity and carbon emission. . In this paper, a comprehensive study has been made to diminish the electrical energy consumption in the two residential hall of University of Dhaka. It highlights the amount of electricity savings respectively is 450 MWh and 433 MWh annually and annually savings of carbon emission is 302 ton and 290 ton of CO_2. The payback period of the total investment to save the electrical energy is 2.45 years. Absence of proper training on electrical energy efficiency, solar photovoltaic installation, development of enough technicians and manpower so that they can effortlessly and reliably install energy efficiency devices, solar equipment, reducing the production cost of energy efficiency components are some key aspects that are still in very initial state.

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