CHAPTER - 1

INTRODUCTION

Bangladesh's economy is growing steadily in the last couple of decades at an average rate of 6.0% annually since 2008. To complement the economic growth to an average of 7% the energy growth needs to be doubled. The increased supply of energy accelerates industrialization, rapid urbanization, infrastructure development and emerging consumer society.

As part of sustainable energy agenda, the government of Bangladesh is actively striving to promote energy efficiency (EE) and energy conservation (EC) program. These are two areas, which are mutually complementary where significant amount of power and energy can be saved and redirected for our economic use in the country.

Energy efficiency (EE) is a way of managing and restraining the growth in energy consumption[1]. Energy efficiency is "using less energy to provide the same service". Something is more energy efficient if it delivers more services for the same energy input, or the same services for less energy input.

Energy conservation (EC) is reducing or going without a service to save energy. Energy conservation refers to reducingenergy consumption through using less of an energy service.

Energy efficiency is not energy conservation.For example turning off a light is energy conservation. Replacing an incandescent lamp with a compact fluorescent lamp (which uses much less energy to produce the same amount of light) is energy efficiency.

Energy efficiency use at every level including generation, transmission, distribution in the supply side and in demand side, introduction of energy efficient household appliances, energy efficient equipments in the industries, CFL bulbs and energy efficient electric fans in households, offices and industries can bring about a significant saving in energy through increased efficiency.

The improvement of energy efficiency and conservation in the country will have primarily a three-fold impact:

I. Improvement of energy security of the country,
II. Meeting the SDG target on time, and
III. Efficient environmental management, thus laying the ground for achieving sustainable development

Through this Energy Efficiency and Energy Conservation campaign, Bangladesh can set a low carbon foot print by lowering carbon emissions through efficient utilization of primary energy and thus contribute to offsetting the negative impact of climate change at the global level.

Problem statement

Gas and petroleum are the main source of primary energy to meet our energy demand. Power sector is the most dominant user of the natural gas and 80% of the total power generation comes from gas, so saving of electricity through electric energy efficiency (EM) and demand side management (DSM) measures would be a direct saving of our valuable and non-renewable gas supplies.

Demand side management (DSM) is a means of using existing energy production facilities more efficientlyby reducing price volatility and improving electric grid reliability[2].Demand-Side Management (DSM) programs is the planning, implementation, and monitoring of utility activities designed to encourage consumersto modify patterns of electricity usage, including the timing and level of electricity demand.It refersto energy and load-shape modifying activities that are undertaken in response to utility-administeredprograms.

The case study building is a resident hall of about two thousand students, situated in the University of Dhaka. This building was built in 1940 and due to yearly increment of resident students; a huge amount of energy is wasted every day in many forms. Students usually don't switch-off electrical equipments that they use in their daily lives. This type of negligence, due to lack of awareness creates a big amount of electricity bill paid by university authority.

In this study we will find out the focal points such as energy used by lighting systems, cooling, heating, cooking, fans, pumps, domestic hot water, and receptacles are affected by the number of occupants, demand schedule, weather, as well as the performance characteristics of the systems and identify Energy Efficient Measures(EEM).Energy Efficient Measures (EEMs) represent specific actions identified that could improve building energy efficiency if applied.

Energy audits may be performed using a simple walkthrough. Simple walkthroughs are typically executed by technical personnel in identifying building operation and maintenance issues. In order to identify effective Energy Efficient Measures(EEMs), the accuracy of the building energy model depends on the input values and assumptions generated by an energy audit.

Research objective

The main objective of this research is to identify that how much energy is actually needed for efficient measured operation of a university hall and how much we consume in an unplanned way now in every day. These differences will reflect the necessity of taking some energy efficient measures to convert this hall into a green, sustainable hall.

The building that we selected for study is seventy five years old and a heritage building. Any major infrastructural change can't happen in near future. So before we make major investments in decreasing the energy consumption it's essential to increase energy efficiency.Energy efficiency provides a far greater return on investment than any non-renewable installations.

In this work we will give some recommendations so that the authority can easily identify the factors of energy waste and take proper steps to reduce energy loss in that specific arena.

Significance

Energy efficiency is the most cost-effective way to mitigate climate change by reducing carbon emissions. Most of the energy we currently produce is wasted in power plants, through transmission, through air leaks in homes and use of inefficient devices at home and offices.

The benefits of energy efficiency are numerous. Taking daily, energy-efficient actionswhile at home, at work and on the go saves energy and money.Energy efficiency saves electricity bills at a large scale. Energy efficiency enhances quality of life by using energy efficient electrical equipment.

Energy efficiency makes daily life of residents more comfortable and productive than before. Energy efficiency makes surety to getting consistent access to electricity forthe inhabitants those who are in remote places of the capital cities.

From power plants to cars, consuming energy produce CO_2 emissions that pollutes our environment every day. But prudent investments in energy efficiency will be the biggest sectors of our economy and eventually it will abate greenhouse gas emissions in a large scale.

Limitation

During the detailed energy audit approach, there was a shortage of necessary tools used to monitor and assess actual building performance. The study was performed using tools that were accessible and readily available. Another limitation is that the scope is focused on one building which is heritage building and adjacentbuildings are almost thirty years old. Thus the results derived only represent a specific circumstance. Conducting the study on more ancient buildings in University of Dhaka would provide stronger evidence for taking the necessity of energy efficiency measures.

CHAPTER – 2

LITERATURE REVIEW

Energy Crisis

To attain a sustainable GDP growth of 7% and above by 2021and beyond it is deemed necessary to meet the essential energy needs of the people. In this regards the Government of Bangladesh (GoB) needs, at the very last , to increase its primary energy supply by 3-4 (2200 million cft/day)times and its electricity generation capacity by approximately 6 times or almost 30000 MW per day.

The nation as a whole is trying to catch up with ICT. The "*Digital Bangladesh*" agenda of government is focused on fast forwarding ICT capacities at all levels to leap-frog the country into standard of 21st century. The prime mover of this agenda and the demands mentioned above will be power supply. Therefore the government has declared a vision of "*Electricity for all by 2021*"

In the conventional power generation sector our country has been able to somewhat reduce the gap between the current demand and supply, through setting up some plants in public and private sectors that have produce the additional power. However as the population grows and the economic activities gear up with rapid urbanization and industrialization , the demand for energy will far out strip the production it is expected.

Subsidy provided to the entire power sector has become unsustainable over the past few years and the government has initiated phase wise withdrawal of subsidy by increasing of the price of electricity, which is unpopular but necessary. A direct impact on the common people of such action is the rise in the living cost along with cost of transportation goes up and as a result the prices of essentials and other food or non-food items rises.

With the growth of economy, the demand of electricity increases to a great extent. Government has prepared a power system master plan to improve and expand electricity supply to support the GDP growth in the 7-8 % range. To meet the demand with reasonable reliability, installed capacity to be increased to 24,000 MW and 39,000 MW by 2021 and 2030 respectively. Given such a GDP growth scenario the demand of electricity both grid and captive is expected to as follows:

Table-1: Electricity demand forecast

Year	Demand in MW
2015	12,000
2020	20,000
2025	25,000
2030	36,000

Although the situation of power generation has changed dramatically in the last years, actual demand could not be met during the last few years because of supply shortages caused by limited generation capacity. The situation has further exacerbated because of shortage of gas supplies to the power plants. On the other hand the quality of life appears to have in the recent years. The overall housing condition has improved in 2015 relative to 2005. The purchasing power of people grew by 15% at the national level as a result the demand of energy is increasing manifold.

Power System Master Plan (PSPM)

In line with this master plan, government has already taken short, mid and long term generation distribution and transmission programs, which are at various stages of planning and implementation levels. According to the existing generation expansion program, total 13000 MW of new generation will be added to the national grid within 2015.

The main objective to formulate a Master Plan[3] (MP) for the attainment of stable power supply in the Bangladesh up to year 2030 in consideration of the diversification of fuel resources, including an optimum power development plan, power system plan, and identification of the potential power plant sites based on the fuel diversification study. Therefore, a study includes a comprehensive power development master plan where the study of the fundamental conditions of the development (demand forecast, procurement of primary energy resources, optimum power development plan, future optimum power supply structure including the positioning of gas-fired power plants, and so on) are added. In addition, the necessary technology transfer to the Counter Part (C/P) in Bangladesh will be carried out during the study.

The Master Plan has taken for the attainment of stable power supply by achieving the 3Es; Economic Growth, Energy Security and Environmental Protection simultaneously. The government of Bangladesh set the maximum target to reduce poverty in a period as swift as possible by achieving high economic growth. Planning electrification via the stabilization and efficiency of the electric power supply system can be expected to reduce poverty. This Master Plan will aim to promote development that will provide a self-reinforcing cycle of poverty reduction and 3E simultaneous achievement. In addition, this Master Plan will help to achieve the vision of '*Electricity for all by 2021*' in line with Government energy policy.

So far, Government of Bangladesh (GOB) has fallen into vicious circle where the power shortage has lasted for long time due to a multiple factor of lack of primary energy resources like domestic natural gas, decrepit power stations, imperfect maintenance and lack of funding. To solve these issues, the GOB focuses on more short-term measurements rather than long-term one. For example, it seems that the national plans such as development plan for domestic primary energy like coal and natural gas, development plan for power and infrastructure plan for fuel transportation are independently formulated by each government division, in which there is no efficient coordination among such plans. Therefore, expected effect for this Master Plan will be to indicate direction for the coordination amongst energy sector, power sector and infrastructure sector based on the certain logic. It is also expected for the Master Plan to show the direction of comprehensive power development plan in long-term basis.

The Importance of Energy Conservation

Energy conservation is saving energy. For example when we turn off a light, we're conserving energy. For example ordinary light bulbs the heat turns into heat so the energy wasted. An energy efficient light bulb turns almost energy of electricity to light not waste it to heat. It is very important to save energy because energy isn't free and unlimited. So everyone needs pay for the energy use that means save energy is save money. Wasting energy is also not conducive to the environment.

We rely on many forms of energy, such as petroleum and natural gas, etc. Most of them are non-renewable. Once they are used up, they are gone forever. On the other hand, most of the energy comes from fossil fuel would cause greenhouse gas emission. So the more energy we save, the more money we save, and the more green our Earth is. Even though energy conservation reduces energy services, it can result in increased environmental quality, national security, personal financial security and higher savings in our daily life. It also lowers energy costs by preventing future resource depletion.

Cooking is another area where a large amount of primary energy is required. Basically fire woods are the most widely used form of biomass for cooking around the country particularly in rural areas which bear the large segment of population. About 82% of people are using fire wood and agricultural residuals for cooking purpose. An amount of 8 million cft of wood are used annually of which 63% is for cooking and 37% is for industrial and commercial purposes. This is leading to rapid deforestation in the country and reducing natural forests which are carbon sinks and thus act against global warming.The introduction of Improve Cook Stove (ICS) can save nearly 50% of primary energy. Each ICS can save 1.7 ton of CO_2 per year thus making a net contribution to global emissions reduction for reducing the effect of climate change. Energy conservation and energy efficiency are both energy reduction techniques.

In Bangladesh about 90% of all harvested rice is parboiled and most of them use conventional boilers. There are nearly 50000 rice husking mills around the country which produce about 28 million tons of rice per year. Improved Rice Husk parboiling system is developed by the Sustainable Energy for development (SED) project of GIZ has demonstrated a saving of up to fifty percent energy used for parboiling. These systems are smoke free and reduce the threat of possible boiler explosion. The SED initiative may save up to 2-4 million tons of rice-husk which can be used to generate electricity.

Solar water heaters are replacing gas and electric heaters in urban areas to reduce energy consumption. Introduction of improved natural gas stove has the potential to replace over 4 million stoves and save 4 billion cubic feet of natural gas per year. The governments' charges for gas used by fixed monthly rates for domestic and industrial consumption rather than on the amount the gas consumed. This encourages the users to keep burners on and thus a huge amount of gas is wasted every day. This can only be stopped by installing gas metersand piloting of prepaid meters are already at different areas of Dhaka city.

Conference of Parties (COP)

The international political response to climate change began at the Rio Earth Summit in 1992, where the 'Rio Convention' included the adoption of the UN Framework on Climate Change (UNFCCC)[4]. This convention set out a framework for action aimed at stabilizing atmospheric concentrations of greenhouse gases (GHGs) to avoid "dangerous anthropogenic interference with the climate system." The UNFCCC which entered into force on 21 March 1994 now has a near-universal membership of 195 parties.

The main objective of the annual Conference of Parties (COP) is to review the Convention's implementation. The first COP took place in Berlin in 1995 and significant meetings since then have included COP3 where the Kyoto Protocol was adopted, COP11 where the Montreal Action Plan was produced, COP15 in Copenhagen where an agreement to success Kyoto Protocol was unfortunately not realized and COP17 in Durban where the Green Climate Fund was created.

The UN Framework Convention on Climate Change (UNFCCC) held its 21st Conference of the Parties (COP 21) from November 30-December 11 in Paris, France. Negotiators from nearly 200 countries will convene to agree on a universal climate agreement. The Paris COP is a pivotal turning point to accelerate the transition to a clean, resilient economy and achieve and build even greater momentum for climate action going forward.

In 2015 COP21, also known as the 2015 Paris Climate Conference**,** will, for the first time in over 20 years of UN negotiations, aim to achieve a legally binding and universal agreement on climate, with the aim of keeping global warming below 2°C

.

Intended Nationally Determined Contributions (INDC)

Countries across the globe committed to create a new international climate agreement by the conclusion of the U.N. Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP21) in Paris in December 2015. In preparation, countries intend to take under a new international agreement, known as their Intended Nationally Determined Contributions (INDCs)[5]. The INDCs will largely determine whether the world achieves an ambitious 2015 agreement and is put on a path toward a low-carbon, climate-resilient future.

The process for INDCs pairs national policy-setting — in which countries determine their contributions in the context of their national priorities, circumstances and capabilities — with a global framework that drives collective action toward a low-carbon, climate-resilient future.The INDCs can create a constructive feedback loop between national and international decision-making on climate change.

INDCs are the primary means for governments to communicate internationally the steps they will take to address climate change in their own countries. INDCs will reflect each country's ambition for reducing emissions, taking into account its domestic circumstances and capabilities. Some countries may also address how they'll adapt to climate change impacts, and what support they need from, or will provide to, other countries to adopt low-carbon pathways and to build climate resilience.

Well-designed INDCs will signal to the world that the country is doing its part to combat climate change and limit future climate risks. A good INDC should be ambitious, leading to transformation in carbon-intensive sectors and industry; transparent**,** so that stakeholders can track progress and ensure countries meet their stated goals; and equitable**,** so that each country does its fair share to address climate change. It is important that INDCs be clearly communicated so domestic and international stakeholders can anticipate how these actions will contribute to global emissions reductions and climate resilience in the future.

An INDC should also articulate how the country is integrating climate change into other national priorities, such as sustainable development and poverty reduction, and send signals to the private sector to contribute to these efforts.

Bangladesh's Intended Nationally Determined Contributions

Bangladesh is a highly climate vulnerable country whose emissions are less than 0.35% of global emissions[6].Without ambitious action to limit greenhouse gases internationally, the future costs of adapting to climate change will be much higher than they are today. If the world fails to take ambitious action, the costs to Bangladesh of climate change could amount to an annual loss of 2% of GDP by 2050 and 9.4% of GDP by 2100. Bangladesh therefore wants to play its part in the global collective action to reduce future emissions as part of a robust and ambitious international agreement.

Consequently, Bangladesh is adopting a two-fold strategy against climate change. The main focus of Bangladesh's activities is on increasing our resilience to the impacts of climate change – which are already affecting the livelihoods of much of our population and will continue to do so in the future. For example, extreme temperatures, erratic rainfall, floods, drought, tropical cyclones, rising sea-levels, tidal surges, salinity intrusion and ocean acidification are causing serious negative impacts on the lives and livelihoods of millions of people in Bangladesh, and are gradually offsetting the remarkable socio-economic development gained over the past 30 years, as well as jeopardizing future economic growth. However at the same time, Bangladesh is also working to achieve lower carbon as well as more resilient development. With this in mind, this INDC aims to put forth mitigation actions that Bangladesh can take to tackle its growing emissions and to play its role in global efforts to limit temperature rise to two degrees or preferably 1.5 degrees above pre-industrial levels.

With respect to Bangladesh's contribution to global efforts to counter climate change, this INDC sets out a number of mitigation actions that will help limit the country's GHG emissions. These mitigation actions will play a key role in realizing the move to a low-carbon, climate-resilient economy and to becoming a middle-income country by 2021 whilst ensuring that it will not cross the average per capita emissions of the developing world. The INDC includes both unconditional and conditional emissions reduction goals for the power, transport, and industry sectors, alongside further mitigation actions in other sectors, which Bangladesh intends to carry out.

Bangladesh intends to implement its conditional emissions reduction goal subject to appropriate international support in the form of finance, investment, technology development and transfer, and capacity building. The foundation of this INDC is Bangladesh's existing strategies and plans, in particular the Bangladesh Climate Change Strategy and Action Plan (BCCSAP), Renewable Energy Policy 2008, the Energy Efficiency and Conservation Master Plan (E&CC Master Plan), the forthcoming National Adaptation Plan, the National Sustainable Development Strategy, the Perspective Plan (Vision 2021) and the Sixth (and forthcoming seventh) Five Year Plan, the National Disaster Management Plan and the Disaster Management Act. In addition, it incorporates the outcome of further analysis and consultation to enhance our existing plans, and to analyze future GHG emissions trends and mitigation and adaptation options.

Energy Audit

Energy Audit is defined as "the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption".Energy audit refers to inspect, investigate and analyze the building, process or system's energy flow to find out their energy dynamics. The purpose of energy audit is to check up whether it is possible to reduce one system's energy consumption without influencing the final output.

The aim of energy audit is also to optimize the energy consumption in order to achieve the upper most cost performance and save energy. To institute the correct energy efficiency programs, first, you have to know which areas in your establishment unnecessarily consume too much energy, e.g. which is the most cost-effective to improve. An energy audit identifies where energy is being consumed and assesses energy saving opportunities. So you get to save money where it counts the most.

Energy audit classification

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.

Usually, energy audit has three main parts; it can stop at any levels. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) define three levels of audits. If analyses stop in part two and three, it mean that it contain the previous parts. The main levels could be included in the process of energy audit:

1. Level I: Site Assessment or Preliminary Audits identify no-cost and low-cost energy savingopportunities, and a general view of potential capital improvements.Activities include an assessment of energy bills and a brief site inspection of yourbuilding.Based on these historical data on use of energy and visual inspection of the facility and operating equipment the results are measures to reduce the cost of the energy.

2. Level II: It is to analyze the energy saving that it is energy efficiency opportunities and quantifies. It would be interesting to seek the probable reasons behind the energy balances. Energy Survey and Engineering Analysis Audits identify no-cost and low-cost opportunities, and also 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.

3. Level III: 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. Some of the energy conservation measures and facility improvements could be performs facility analysis in this level. It is necessary to give the results when some of the measures are applied to achieve these results. In addition to Level I and LevelII activities, Level III audits include monitoring, data collection and engineering analysis.

The energy auditor we select will work with us to understand our project goals and available budget, and help us determine which level of audit we need. For smaller facilities where there is no major capital improvement plan or budget, a Level I audit could yield results that make the cost of the audit worthwhile. If we have a larger facility that has never been audited, a Level II or Level III audit would be more appropriate due to the complexities of systems and potential savings opportunities.Level II and Level III audits are more expensive, but are good options if we have defined energy efficiency goals but not yet taken action, or if you have plans for a major renovation or equipment upgrade. These audits should include a preliminary feasibility study (often provided by potential energy auditors free of charge) to scope the energy saving opportunities and ensure that the cost of the energy audit is worth the savings payoff.

Energy efficiency measures

Energy Efficient Measures (EEMs) represent specific actions identified that could improve building energy efficiency if applied. Energy efficiency can be said to be the cheapest form of new source of energy. It actually minimizes wastage of energy without affecting productivity and human comfort. Energy efficiency and energy conservation involve all sectors of economy. Motors and drive systems in industry and agriculture sectors consume major chunks of energy. So it is advisable to use efficient and correct capacity motors. Considerable reduction in energy consumption is also possible by reducing high lighting levels in domestic, commercial and industrial installations. The thermal system EEMs specifically affect the thermal comfort and performance of thermal systems in the building, while the electrical system EEMs specifically affect the amount of electricity being used.

For residential purpose we can use energy efficient internal wiring e.g. which uses intelligent devices like position sensors, timers, door switches. This kind of wiring also provides options for energy saving mode and normal mode of using appliances more efficiently.

Energy Star

Energy Star is a government-backed[7] labeling program that helps people and organizations save money and reduce greenhouse gas (GHG) emissions by identifying factories, office equipment, home appliances and electronics that have superior energy efficiency. Any building or product that has received an Energy Star rating carries a logo such as blue. Energy Star is a voluntary labeling system, though most manufacturers find it commercially desirable to display the logo if their products qualify. The standards themselves, however, are set by governmental agencies.

Energy Star provides online assessment tools that allow businesses and consumers to rate the efficiency of homes and industrial facilities. Energy Star ratings have become an important component of buying decisions for both consumers and businesses. More efficient buildings, appliances and hardware mean significant savings over time on heating or power costs.

Adoption of energy efficient practices are an important component of the green computing movement, both in terms of lower operating costs and reduced pressure on the energy grid. This in turn over time reduces, if not halts, the growth in greenhouse gasses emitted by coal-fired energy plants. These gasses, according to recent reports from the Intergovernmental Panel on Climate Change are the major component in the rapid warming of the Earth over the past century, a development which has potentially disastrous results for both humans and ecosystems in general worldwide.

Energy Star Labeling Program

A large instrument will be necessary to launch the energy star program. Sustainable And Renewable Energy Development Agency (SREDA) Act and EE & EC rule will provide legal support to start this program. A regulation will be formulated for proper implementation of this program. Awareness generation will be needed for the industries/importers/other stakeholders to embrace this program. Hence, number of seminars will be arranged involving different stakeholders.

The Government of Bangladesh (GoB) is assisting the Bangladesh Standards and Testing Institution (BSTI) to develop energy standards and leveling with improve mitigation technology for six common electrical appliances e.g. (1) air-conditioners, (2) refrigerators, (3) electric fan, (4) electric motors, (5) electronic ballast, (6) CFL. This will help to promote energy efficient equipment to the end user at domestic and commercial sectors. The "*Digital Bangladesh*" agenda of government is focused on fast forwarding ICT capacities at all levels. The computer is one of the major equipment for building a digitally vibrant society based on ICT. Computers were one of the first devices in the history to be rated by Energy Star.

In general, computer energy consumption can be reduced in two ways: by using components that require less power or by using power management software to modulate the energy consumption of these components. Energy Star ratings are available for desktop computers, laptops, workstations and gaming consoles. If every household and business replaced old computers with new Energy Star-qualified models, we will save a huge amount of energy, avoiding greenhouse gas emissions that emitted by coal-fired energy plants. Similarly, Energy Star-qualified florescent bulbs consume up to 75% less energy than standard incandescent bulbs to provide the same amount of light, and last up to 10 times longer.

Energy Efficiency Scenario In Bangladesh

Primary energy consumption in Bangladesh is one of the lowest in the world. In 2008, the country's per capita annual energy consumption was 182 kgoe and per capita electricity generation at 236 khw until recent years. Despite intensive efforts to increase coverage, 74% percent of total population has now access with per capita electricity generation of 341 khw in 2015. Bangladesh's present power generation capacity is 7500-8500 MW (excluding 2200MW captive generation).

At present, both renewable and non-renewable sources contribute to total energy consumption. Currently about 70% of power generation is based on natural gas which was almost 90% in 2009. About 55% of the country's energy supply is based on traditional fuels (crop residues, animal dung and fuel wood), 24% on natural gas, 19% on imported oil and coal and the remaining 2% is hydro-electricity.

The use of oil as an energy source in the corresponding period has shown increasing trends; in 2009, oil represent 11.15% of total energy supply and in 2010 it is 18.3% and 23.8% in 2011. Now in 2015 the use of imported oil is almost 20% of total energy supply. In line with power system master plan, the government has already taken short, mid and long term generation, distribution and transmission programs, which are at various stages of planning and implementation level.

Of total generation of 45,836 Million kilo-watt hour (MkWh) in 2014-15, the share of gas, hydro, coal and oil based generation are 69.44%, 1.24%, 2.05% and 19.89% respectively. Although the situation of power generation has changed dramatically in the last year, actual demand could not be met during the last few years because of supply shortages caused by limited generation capacity government is trying to import electricity from neighboring country. Its almost 5.37% of total energy generation in 2014 and in 2015 it reaches to 7.37%.

Table-2 : Generation pattern based on primary fuel

Fiscal year	Total production (MkWh)	Gas (%)	Coal (%)	Liquid fuel (%)	Hydro electricity (%)	Imported generation (%)
2013-14	42,195	72.42	2.46	18.35	1.39	5.37
2014-15	45,836	69.44	2.05	19.89	1.24	7.37
2015-16(possible)	50,587	70.55	1.56	19.48	1.31	7.10
2016-17(possible)	56,691	72.52	1.66	17.78	1.03	7.00

CHAPTER – 3

METHODOLOGY

The methodology developed is used to compare the accuracy of the energy audits. FazlulHuque Muslim Hall was selected as the case study building due to the availability of detailed information, as well as, general familiarity. Night and weekend access was granted to the researcher to conduct this study. The two audits to be compared are illustrated in the figure 1 the various stages are listed on the left with each audit approach outlined in a column to the right. Approach #1 represents a general audit based off of the construction documents and general familiarity of the building. Typically, such an audit is conducted in-house in order to keep initial costs down while not exerting a rigorous amount of detail and effort in improving energy performance.

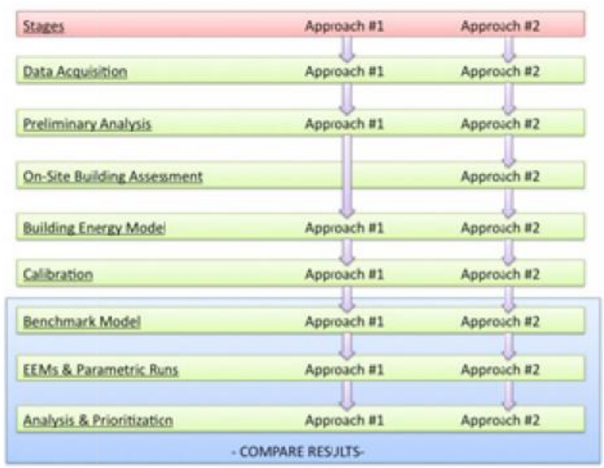


Figure -1: Flow chart of an energy audit

Approach #2 represents a more professional audit as conducted in the Level II energy audit. Typically this type of audit would be conducted by an ESCO company, energy engineer, or even a commissioning agent to identify how the actual building is performing. In order to separate the data generated from each audit, approach #1 will be conducted first, and the information gathered will then be modeled. Once this is complete, Approach #2 will be conducted and the details found will be entered into a separate energy model.

The highlighted blue box indicates the stages that produce results which can be compared to one another. Following the figure is a detailed description of each stage that will reveal its importance in identifying EEMs. At the end of this procedure, one of the two approaches will identify more accurate energy efficiency measures. The hypothesis is that a more detailed energy audit along with the use of a dynamic simulation tool will provide more accurate energy model in how the building performs. The accuracy of the model will generate EEM values with higher confidence of quantified energy savings. Potentially, the accuracy of energy saved will justify the use of a detailed energy audit.

Site Survey

We choose a resident hall of University of Dhaka, named Fazlul Haque Muslim hall was built in 1940. It is consists of a heritage building called Main building, a 4 stored building named South building, a provost office in which ground floor is used for administrative work of hall and top floor is used as a

Location picture-1: Front view

Location picture -2 : East side view

mosque, a 3 storey building in which ground floor is used as a canteen and upper two floors is used as reading room. There are also a laundry room a saloon for hair dressing and a dining hall. At west there is a pond, at north some buildings of Curzon hall, at east the main road, at south the Amar Ekushe hall is situated.

Location picture -3: Top floor view

.

On-Sight Building Assessment

The on-site building assessment stage is only used for a detailed energy audit walkthrough of Fazlul Haque Muslim Hall is conducted in accordance to the Level I audit. During the on-site building assessment, many measurements will be made to verify the building's actual performance and operations compared to its original design. For example, a visit into the mechanical will allow for reading of various meters such as temperature gauges, flow meters, and VFD displays.

Location picture-4:Top floor view of East block

Location picture -5: Provost Office view

Additionally, hooking up a Watt meter to electrical systems will indicate the actual amount of electricity drawn over a given period of time. Additionally, a series of interviews should be conducted to aid in determining proper scheduling, characteristics of various systems, major equipment loads, space functions, operation and maintenance characteristics, etc. Once this information is gathered, then it is possible for detailed energy audit to identify EEMs opportunities.

Measuring Devices

To measure the energy consumptionsmonitoring equipments must be implemented onto the strategic points. Taking into account the several states in which energy can be found, different metering equipment is necessary. The following table provides an overview of the equipments for an energy audit.

Table-3: Equipment used in a detailed energy audit

Type	Instruments name	Measured parameters
Electrical	Voltmeter	It measures the voltage or voltage drop in the grid or electrical circuits.
	Ammeter	It measures the current absorbed by appliances and motors
	Ohmmeter	It measures the resistance of various loads.
	Multi-meter	It can measure voltage, current, resistance.
	Watt-meter	It can measure active power /instant power demand of appliances, motors or the power performance of generators.
	Power factor meter	It can measure power factor of the building.
	Light meter	This tool measures the amount of illumination a surface has. The unit of measure is in foot-candles.
Thermal	Thermometer	It can be used in identifying temperatures(^{0}c) within systems, spaces etc.

Figure -2:Power meter

Figure -3: Light meter

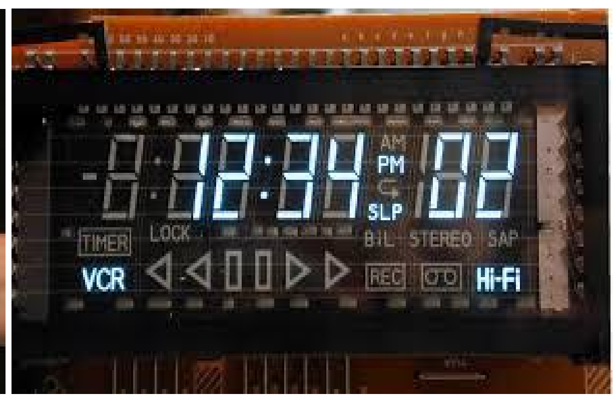


Figure -4: VFD display

All the above instruments are usually portable. They are connected to the wiring with the use of nippers and they could feature a data-logger. Measurements of electrical power and energy consumption should be made on all energy intensive areasand installations. Since these instruments are generally not expensive, it is advised to examine their permanent installationin some of the above cases.

Data Acquisition

South building:

The area of a living room is 20' × 15' = 300 sq. ft
The height of a living room is 10 feet.
In this room generally 8 students are allotted. Electrical energy consuming apparatus are table fan (40w), tube light (55 W), ceiling fan (105 W), table lamp (12 W), computer (150 W), laptop (50 W), mobile chargers (4 W) etc are heavily used in everyday life of the students.

Table fans consumption is 4×40(W) ×18(hr) = 2880Wh
4 feet Tube light consumption is 2×55(W) ×15(hr) = 1650Wh
Ceiling fan consumption is 2×105(W) ×20(hr) =4200Wh
Table lamp consumption is 4×60(W) ×10(hr) = 2400 Wh
Laptop consumption is 4×50(W) ×20(hr) = 4000 Wh
Mobile charger consumption is 10×4(W) ×24(hr) = 960 Wh
Computer consumption is 2×150(W) ×20(hr) = 6000Wh

Total usages in a day is 22090Wh= 22.09 kWh
Each floor contains 19 living rooms. There are four floors in the south building. The total usage of these 19 rooms is = No of room ×No of floor × Energy usage in a single room
= 19× 4 ×22.09 kWh
= 1678.84 kWh

Each floor contains 2 bathrooms.
Energy consumption in a bathroom is = 3× 55(W) × 24(h) = 3960Wh
Total no of bathrooms in the south building is eight (8).
Total energy consumption in these bathrooms is = 8× 3960 (Wh) = 31680Wh = 31.68 kWh

A water pump that is used to supplying for drinking and other daily needs. So the daily energy consumption caused by water pump is 746(W) × 4(h) = 2984Wh

A few printers are also used for printing study materials. The consumption of these printers is = 6× 50(W) × 1(h) = 300Wh
Total electrical energy used by the south building is = (1678.84 +31.68+2.984+0.3)kWh

= 1713.842 kWh

Main building:

In the main building total 170 rooms are allocated for students. Among these room there are 18 single room that means a single student is residing and the rest 152 rooms are double which means two students live in these room.

The area of a single room is (15' ×7') = 105 sq ft. The area of a double room is (15' ×10') = 150 sq ft.

The height of all the rooms (single or double)is same and it is 15 feet.

Energy consumption in a single room is calculated by the electrical devices that the students are using in their daily lives.

Single room:-

4 feet Tube light consumption is 1×55(W) ×18(hr) = 990 Wh
Ceiling fan consumption is 1×105(W) ×20(hr) = 2100Wh
Table lamp consumption is 1×60(W) ×6(hr) =360 Wh
Computer consumption is 1×150(W) ×15(hr) = 2250 Wh

Mobile charger consumption is 1×6(W) ×24(hr) =144 Wh
Total consumption in a single room is = 5844Wh = 5.844 kWh
Total consumption in all 18 single room is = 5844 (Wh) × 18 = 105192Wh = 105.192 kWh

Double room:-

Now we calculate energy consumption in a double room.

4 feet tube light consumption is 2×55(W) ×18(hr) = 1980Wh
Ceiling fan consumption is 1×105(W) ×20(hr) = 2100 Wh
Table lamp consumption is 2×60(W) ×6(hr) = 720 Wh
Computer consumption is 1×150(W) ×15(hr) = 2250 Wh
Mobile charger consumption is 2×6(W) ×24(hr) = 288 Wh
Table fans consumption is 1×40(W) ×18(hr) = 720 Wh
Laptop consumption is 1×50(W) ×20(hr) = 1000 Wh
Total consumption in a double room is = 9058Wh = 9.058kWh
Total consumption in all 152 double room is = 9.058 (Wh) × 152 = 1376816Wh = 1376.816kWh
A few printers are also used for printing study materials. The consumption of these printers is = 6× 50(W) × 1(h) = 300Wh

Bathroom:

No of bathroom in the main buildings is six (6).

Total energy consumption in these bathrooms is = 6× 3960 (Wh) = 23760Wh = 23.760kWh
A water pump of a single H.P. is used to supplying for drinking and other daily needs. So the daily energy consumption caused by water pump is 746(W) × 5(h) = 3730Wh = 3.73 kWh

Corridor light:

There are almost thirty 4 feet (30) tube lights to illuminate the premise. The energy used by this lights is 30×55(w) ×12(hr) = 19800Wh =19.8 kWh

The overall energy consumption in main building is = (105.192+1376.816+0.3+23.76+3.73+19.8)kWh

= 1527.868 kWh

Mosque:

4 feet tube light consumption is 20×55(W) ×5(hr) = 5500 Wh
Amplifier consumption is 6×10(W) ×2(hr) = 120 Wh
Ceiling fan consumption is 23×105(W) ×2(hr) = 4830Wh
Microphone consumption is 1×100(W) ×2(hr) = 200 Wh

Total consumption in a mosque is = 10650Wh = 10.65 kWh

Provost office:

4 feet tube light consumption is 23×55(W) ×9(hr) = 11385Wh
Ceiling fan consumption is 12×105(W) ×9(hr) = 11340Wh
Printer consumption is 2×50(W) ×4(hr) = 400 Wh
Computer consumption is 2×150(W) ×9(hr) = 2700 Wh
Air conditioner consumption is 1×1000(W) ×5(hr) = 5000 Wh
Total consumption in a mosque is = 30825Wh = 30.825 kWh

Saloon:

4 feet tube light consumption is 4×55(W) ×15(hr) = 3300 Wh
Ceiling fanconsumption is 2×105(W) ×15(hr) = 3150 Wh
Hair trimmer consumption is 2×300(W) ×1(hr) = 600 Wh
Electric shaver consumption is 2×15(W) ×1(hr) = 30 Wh
Total consumption of the saloon is = 7080 Wh = 7.08 kWh

Iron room:
4 feet tube light consumption is 3×55(W) ×18(hr) = 2970Wh
Ceiling fan consumption is 2×105(W) ×15(hr) = 3150 Wh
Electric iron consumption is 2×1000(W) ×16(hr) = 32000 Wh

Total consumption of the iron room is =38120Wh = 38.120 kWh

Reading room:

4 feet tube light consumption is 24×55(W) ×20(hr) = 26400Wh
Ceiling fan consumption is 18×105(W) ×20(hr) = 37800Wh

Total consumption of the reading room is = 64200Wh = 64.2 kWh

Canteen:

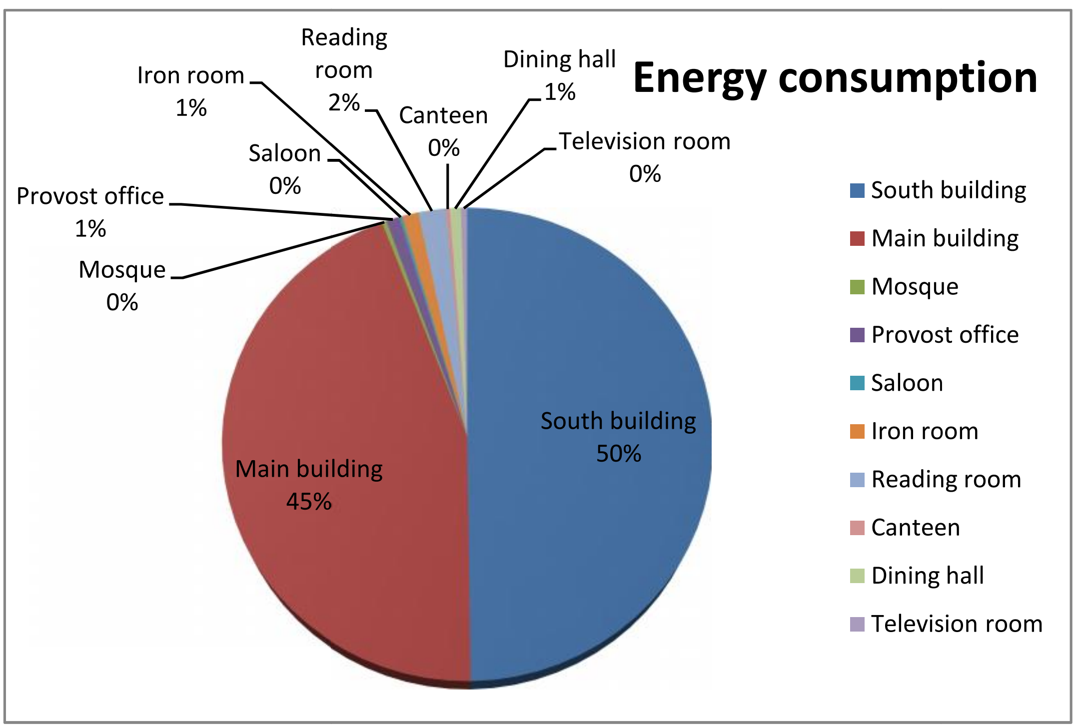
4 feet tube light consumption is 7×55(W) ×9(hr) = 3465Wh
Ceiling fan consumption is 6×105(W) ×9(hr) = 5670Wh
Total consumption of the canteen is = 9135Wh = 9.135 kWh

Dining hall:
4 feet tube light consumption is 24×55(W) ×9(hr) = 11880Wh
Ceiling fan consumption is 14×105(W) ×6(hr) = 8820Wh
Refrigeration consumption is 2×450(W) ×6(hr) = 5400 Wh
Total consumption of the dining hall is =26100Wh = 26.1 kWh

Television room:
4 feet tube light consumption is 10×55(W) ×9(hr) = 4950Wh
Ceiling fan consumption is 10×105 (W) ×8(hr) = 8400Wh
52' led television is 1×70(W) ×10(hr) = 700 Wh
Total consumption of the television room is =14050 Wh = 14.05 kWh

Table -4 : Consumption scenario in different location of the hall

Building name	Energy consumption (kWh)
South building	*1713.8*
Main building	*1527.86*
Mosque	*10.65*
Provost office	*30.82*
Saloon	*7.08*
Iron room	*38.12*
Reading room	*64.2*
Canteen	*9.13*
Dining hall	*26.1*
Television room	*14.05*
Total	*3441.8*



Graph -1: Energy consumption in different locations in the hall

In a day Fazlul Haque Muslim hall consume the electrical energy = 3441.8 kWh

So annually this hall consumes about 1255.76 MWh of electrical energy.

Analysis

i) Preliminary Analysis

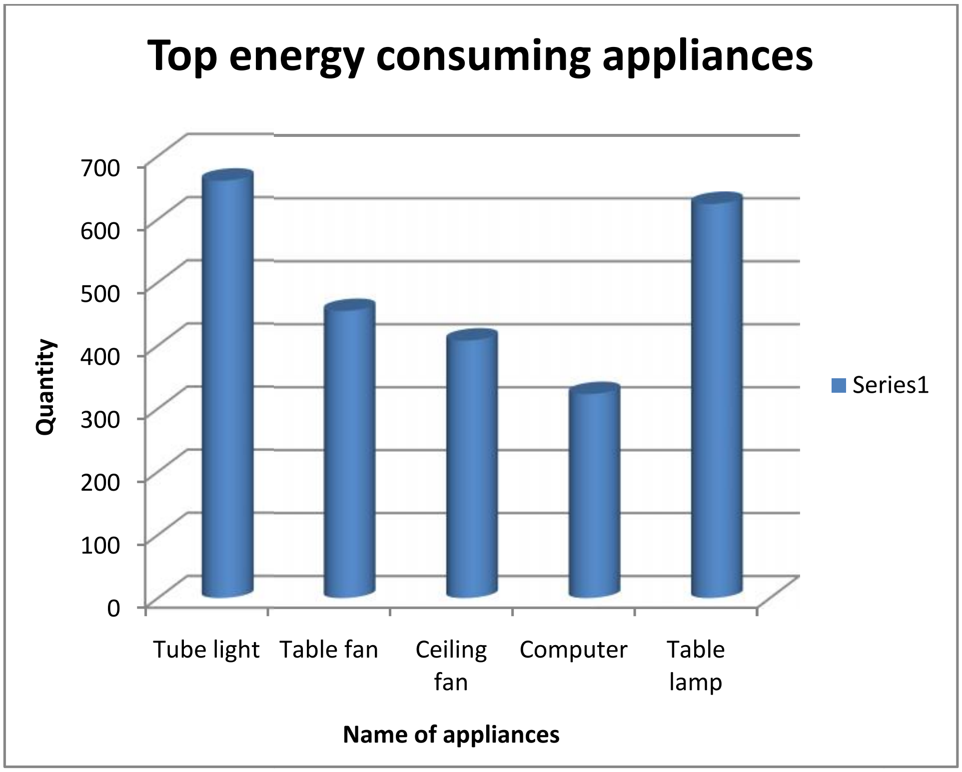
Building energy consumption values were not obtained because the south building is almost 35 years old and the Main building just cross its historic 75 years anniversary. The energy consumed in Fazlul Huque Muslim Hall is supplied by only one energy source and that is electricity comes from local utility suppliers named DPDC. Quantities of the lights are counted throughout visual inspection within each zone to help identify the Lighting Power Densities (LPD). In this hall there is no use of artificial ventilation; due to the natural ventilation in summer the average temperature in a room is 25^0c which is much comfortable in summer. During winter the average temperature fall down to 16^0c. the height of the rooms in main building is 15'. This height can easily blow out the hot ear of the room and make living comfortable. The wall of the room is about 1' thick which can absorb heat in summer and in winter it creates insulation from cold wave.

In these rooms the students use various types of electronic devices that consume a lot of energy. In the south facing room there is no need to incorporate any kind of extra load for cooling the room. The west facing rooms get highest temperature in summer. For this reason the residents of the east block rooms are consuming more energy than other two blocks. From the survey we get the consumption pattern of the student. They used to operate computer all the time in the room particularly desktop. They continue the operation such as download from interneteven if they go outside. The unconsciousness of students makes waste of a huge amount of electrical energy.

If we analysis the consumption pattern almost 50% of total consumed energy is occurs by south building, and 44% by main building. So focus should be given to these two building to reduce the energy loss at a significant rate. If we think about renewable energy then there is a lot of space on the roof. In south building, more than 5000 sq ft of idle rooftop creates an opportunity to set up PV panels that helps too supply clean electricity. Similarly in the main building have more than 10000sq ft of rooftop. Besides these, the provost office also has about 5500sq ft of roof top.

ii) Load Analysis

The electrical loads that are used in daily life are most common type such as tube-light(55 W), ceiling fan(105 W), computer(150 W), table fan (40 W), incandescent light(60 W), water pump(400 W), refrigerator(450 W), air-conditioner(1500 W), mobile charger(4 W), laptop(50 W) etc. In this hall there are more than 650 tube lights uses in every day. More than three (3) hundred desktop computers and laptops are in operation every day. About 250 old fashioned ceiling fans are also caused a lot of waste of electrical energy. Refrigeration, water pump are need to be replaced because they are almost 5 years old. The older electrical motor makes more the waste.



Graph -2: The appliances that consume most energy

We now show you that how much energy is consumed every day in peak hour.

South building:

Table fans consumption is 4×40(W) ×5(hr) = 800 Wh
4 feet tube light consumption is 2×55(W) ×5(hr) = 550 Wh
Ceiling fan consumption is 2×105(W) ×5(hr) = 1050 Wh
Table lamp consumption is 4×60(W) ×5(hr) = 1200Wh
Laptop consumption is 4×50(W) ×5(hr) = 1000 Wh
Mobile charger consumption is 10×4(W) ×5(hr) = 200 Wh
Computer consumption is 2×150(W) ×5(hr) = 1500Wh

Total usages in a day is 6300 Wh= 6.3 kWh
Each floor contains 19 living rooms. There are four floors in the south building. The total usage of these 19 rooms is = No of room ×No of floor × Energy usage in a single room
= 19× 4 ×6.3 kWh

= 478.8 kWh

Each floor contains 2 bathrooms.
Energy consumption in a bathroom is = 3× 55(W) × 5(h) =825Wh
Total no of bathrooms in the south building is eight (8).
Total energy consumption in these bathrooms is = 8× 825 (Wh) = 6600Wh = 6.6 kWh
Total electrical energy used by the south building during peak hour is = (478.8 + 6.6)kWh

= 485.4 kWh

Main building:

In the main building total 170 rooms are allocated for students. Among these rooms there are 18 single rooms that mean a single student is residing and the rest 152 rooms are double which means two students live in a room.

Single room:-

4 feet tube light consumption is 1×55(W) ×5(hr) = 275 Wh
Ceiling fan consumption is 1×105(W) ×5(hr) = 525 Wh
Table lamp consumption is 1×60(W) ×6(hr) =360 Wh
Computer consumption is 1×150(W) ×5(hr) = 750 Wh
Mobile charger consumption is 1×6(W) ×5(hr) =30 Wh
Total consumption in a single room is = 1940Wh = 1.94 kWh

Total consumption in all eighteen (18) single room during peak hour is = 1715(Wh) × 18 = 34920Wh =34.92 kWh

Double room:-

Now we calculate energy consumption during peak hour in a double room.
4 feet tube light consumption is 2×55(W) ×5(hr) = 550 Wh
Ceiling fan consumption is 1×105(W) ×5 (hr) = 525 Wh
Table lamp consumption is 2×60(W) ×6(hr) = 720 Wh
Computer consumption is 1×150(W) ×5(hr) = 750 Wh
Mobile charger consumption is 2×6(W) ×5 (hr) =60 Wh
Table fans consumption is 1×40(W) ×5 (hr) = 200 Wh
Laptop consumption is 1×50(W) ×5 (hr) = 250 Wh

Total consumption in a double room is = 3055Wh = 3.055 kWh
Total consumption in all 152 double room during peak hour is = 3.055 (Wh) × 152 = 464360Wh = 464.36 kWh

Bathroom:

No of bathroom in the main buildings is six (6).

Total energy consumption in these bathrooms during peak hour is = 6× 3× 55(W) × 5(h) =4950 (Wh) = 4.95 kWh

Corridor light:

There are almost thirty (30) 4 feet tube lights to illuminate the premise. The energy used by this lights during peak hour is 30×55(W) ×5 (hr) = 8250Wh = 8.25 kWh

The overall energy consumption in main building during peak hour is = (34.92 + 464.36 + 4.95+8.25) kWh = 512.48 kWh

Saloon:

4 feet tube light consumption is 4×55(W) ×5(hr) = 1100Wh
Ceiling fan consumption is 2×105(W) ×5(hr) = 1050 Wh
Hair trimmer consumption is 2×300(W) ×1(hr) = 600 Wh
Electric shaver consumption is 2×15(W) ×1(hr) = 30 Wh
Total consumption of the saloon during peak hour is =2840 Wh = 2.84 kWh

Iron room:

4 feet tube light consumption is 3×55(W) ×5 (hr) = 825 Wh
Ceiling fan consumption is 2×105(W) ×5 (hr) = 1050 Wh
Electric iron consumption is 2×1000(W) ×5 (hr) = 10000 Wh

Total consumption of the iron room during peak hour is =11875Wh = 11.875 kWh

Reading room:

4 feet tube light consumption is 24×55(W) ×5 (hr) = 6600 Wh
Ceiling fan consumption is 18×105(W) ×5 (hr) = 9450Wh

Total consumption of the reading room during peak hour is =16050Wh = 16.05 kWh

Canteen:

4 feet tube light consumption is 7×55(W) ×3(hr) = 1155 Wh
Ceiling fan consumption is 6×105(W) ×3(hr) = 1890 Wh
Total consumption of the canteen during peak hour is = 3045 Wh = 3.045 kWh

Dining hall:

4 feet tube light consumption is 24×55(W) ×3(hr) = 3960Wh
Ceiling fan consumption is 14×105(W) ×3(hr) = 4410Wh
Refrigeration consumption is 2×450(W) ×3(hr) = 2700 Wh
Total consumption of the dining hall during peak hour is =11070Wh = 11.07 kWh

Television room:
4 feet tube light consumption is 10×55(W) ×5(hr) = 2750Wh
Ceiling fan consumption is 10×105 (W) ×5(hr) = 5250Wh
52' led television is 1×70(W) ×5(hr) = 350 Wh
Total consumption of the TV room during peak hour is = 8350Wh = 8.35 kWh

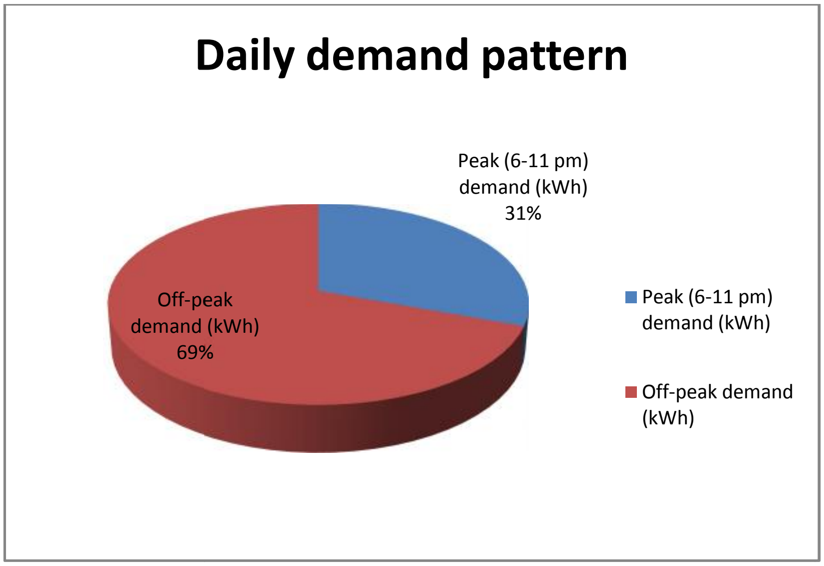
Table-5:Energy consumption of hall during peak hour

Building name	Energy consumption(kWh) in peak hour (6-11 pm)
South building	485.4
Main building	512.48
Saloon	2.84
Iron room	11.875
Reading room	16.05
Canteen	3.045
Dining hall	11.07
Television room	8.35
Total	*1051.11*

In a day Fazlul Haque Muslim hall consume the electrical energy in peak time = 1051.11 kWh

Table-6: comparison of peak and off-peak demand

Daily demand (kWh)	Peak (6-11 pm) demand (kWh)	Off-peak demand (kWh)
3441.448	*1051.11*	*2390.338*



Graph-3: Daily demand pattern in the hall

iii) Cost Analysis

When we get all kinds of electrical data, we have to analyze the loads where we will recommend various types of energy efficiency measures. While analyzing the load of living rooms we saw some drawbacks. The unit of electricity consumed by the students of the hall is a huge amount per day. This big amount of electricity unit has been paid by university authority as utility bill. To insert into more clear view of cost of this consumed electricity we have to divide the time interval into two slabs called peak hour and off-peak hour.

From data analysis of daily energy usage in peak hour (6-11 pm) the demand is 1051.11 kWh and demand in off-peak hour is = (3441.84- 1051.11) = 2390.714 kWh.

According to the current tariff fixed by government's power distribution company in Dhaka[8] (DPDC & DESCO),this hall has fallen into the F category: Medium Voltage, General Purpose (11 KV). From the tariff schedule, in peak hour the rate of per unit i.e. per kWh is 9.57 taka and in off –peak hour per unit rate is 6.88 taka.

The bill that is made by consumption in peak hour is = (1051.11 × 9.57) taka

= 10059.12 taka

The bill that is made by consumption in off-peak hour is = (2390.714 × 6.88) taka

= 16438.64 taka

Total electricity bill in every day is = (16438.64 + 10059.12) taka

= 26497.76 taka

Table-7: Cost of electricity bill per day

Peak (6-11 pm) hour bill (taka)	Off -peak hour bill (taka)	Total daily electricity bill (taka)	Monthly electricity bill (taka)	Annually electricity bill (taka)
10059	16438	26497	*794933*	*9671684*

The five key devices that consume most energy are computer, tube light, table lamp, table fan and ceiling fan. We calculate that these five devices cumulatively consume almost 28000 kWh or 2800 unit of electricity. So it can be assumed that almost 1400 unit from total 3441consumed unit is being wasted every day. The price of these wasted units is about 11059.77 tk. To save this amount we have to invest our money to buy energy efficient LED light, fan, computer, LED monitor and other energy star devices.

iv) Prioritization

If we replace tube light by energy star rated CFL then we save three times energy. A 4 feet tube light can consume 55W, where a T-6 CFL tube light consumes only 12W to illuminate same area as before. Total no of tube light is about 662. If we replace these inefficient tube lights with energy star rated T-6 or T-8 tube light then we can save 417.846 kWh energy every day.

Ceiling fan is also mandatory equipment that use in summer heavily. During summer almost 9 months of a year in Dhaka temperature is moving around 28-36^{0}c. In this time ceiling fan is heavily used in room. The ceiling fans that are used in living rooms of students are not really efficient. Using energy star rated modern ceiling fan can save a lot of valuable electricity bill. Energy efficiency and conservation will be promoted where the no of appliances are very large. This will help to contract the energy waste.

Ceiling fan as well as electric motors is also in recent days got energy star ratings. Using components such as high efficiency motor in ceiling fan reduce a lot of energy.There are about 409 ceiling fan in the hall. If we replace these fans with energy efficient fan that consume only 55-65 W, then we can save an amount of 289.04kWh energy per day. Eventually it will save a lot of money and reduce carbon emission to live for a better world.

Computers were one of the first devices to be rated by Energy Star. In general, computer energy consumption can be reduced in two ways: by using components that require less power or by using power management software to modulate the energy consumption of these components. Energy Star ratings are available for desktop computers, laptops. So using energy star labeled computers and laptop may reduce tremendous amount of electricity bill.

A desktop computer is less energy efficient than a laptop one. A desktop computer consists of monitor, CPU, speakerand other peripheral devices. Among them monitor is energy consuming appliance. If the computer is old then it may be use a CRT monitors as an output device. A CRT monitor of 15-17' screen may consume about 80-90W of electrical energy where replacing a CRT with a LED monitor of rated power 30-36W will save a lot energy and electric bill. In this hall it is assumed that over 300 desktop computer are in operation every day.

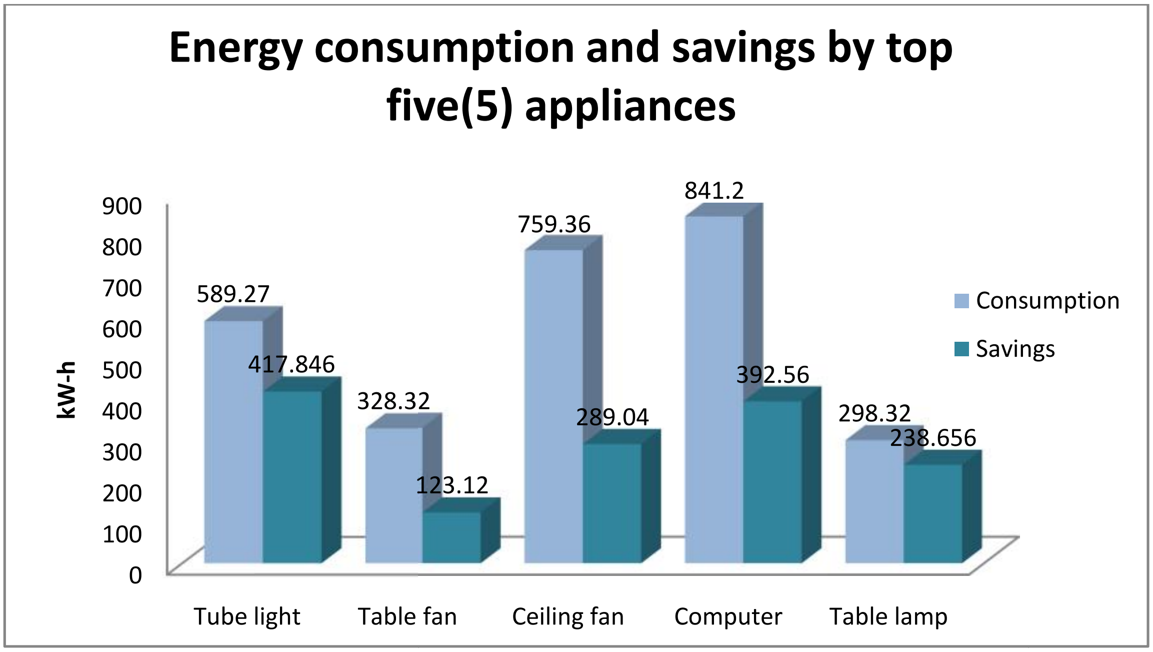
In a table lamp students generally used incandescent bulb of 60W which can waste a lot of electrical energy. This type of light emits a lot of heat and this heat comes from utilizing electrical energy. If we replace the 60w incandescent by CFL light of 10W then we will save a lot bill.

Refrigeration, water pump, air condition are need to be replaced at a regular interval of five (5) year, so that they can deliver high efficiency. This high efficiency will give us a smiling face by saving a lot of electric bill. High efficiency electrical motors can save up to 45% of electrical energy.

Table-8: Top five major devices that save most electrical energy

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	661	55	39	589.27	417.846
Table fan	456	40	15	328.32	123.120
56 inch ceiling fan	409	105	40	759.36	289.04
Computer	324	150	70	841.2	392.56
Table lamp	626	60	48	298.32	238.656

Gas burner in our dining hall wastes a lot of natural gas by cooking food. We don't care about the loss of gas. There is no accurate measuring instrument like meter in the kitchen so that we can easily detect the loss of our valuable natural gas. Using improve cooking stove can reduce the waste of gas. There is a bad habit in the students that they never turn off any electrical device they go out of work. If we set occupancy sensors to turn off when no one is present in a room it will reduce the loss or waste of energy.



. Graph-4: Savings and Consumption at a glance

v) Energy Saving Calculation

The area of a living room is 20' × 15' = 300 sq. feet
The height of a living room in south building is 10 feet.
In this room generally 8 students are allotted.
Electrical apparatus which are energy star rating save a lot of energy. Energy star rated table fan saves 15W, T-6 tube light saves up to 39W, ceiling fan can save 30W, table lamp saves 48W, computer saves 70W , water pump save 200 W , refrigerator can save 250 W etc. that used in everyday life of the students.
Table fans saving is 4×15(W) ×18(hr) = 1080 Wh
T-6 tube light saving is 2×39(W) ×15(hr) = 1170Wh
Ceiling fan saving is 2×40(W) ×20(hr) = 1600 Wh
Table lamp saving is 4×48(W) ×10(hr) = 1920 Wh
Computer saving is 2×70(W) ×20(hr) = 2800 Wh

Total usages in a day is 8570Wh = 8.57 kWh
Each floor contains 19 living rooms. There are four floors in the south building. The total saving of these 19 rooms is = No of room ×No of floor × Energy usage in a single room
= 19× 4 ×8.57 kWh
= 651.32 kWh

Each floor contains 2 bathrooms.
Energy saving in a bathroom is = 3× 39 (W) × 24 (h) = 2808Wh
Total no of bathrooms in the south building is eight (8).

Total energy saving in these bathrooms is = 8× 2808 (Wh) = 22464Wh = 22.464 kWh

A water pump that is used to supplying for drinking and other daily needs. So the daily energy saving by energy star rated water pump is 200 (W) × 4(h) = 800Wh

Total electrical energy saved in the south building is = (651.32 +22.464 +0.8)kWh

= 674.584 kWh

Main building:

In the main building total 170 rooms are allocated for students. Among these rooms there are 18 single rooms that mean a single student is residing and the rest 152 rooms are double which means two students live in these room.

The area of a single room is (15' ×7') = 105 sq ft. The area of a double room is (15' ×10') = 150 sq ft. The height of all the rooms (single or double)is same and its 15 feet.Energy saving in a single room is calculated by the electrical devices that the students use in their daily lives.

Single room:-

T-6 tube light saving is 1×39(W) ×18(hr) = 702 Wh
Ceiling fan saving is 1×40(W) ×20(hr) = 800 Wh
Table lamp saving is 1×48(W) ×6(hr) = 288 Wh
Computer saving is 1×70(W) ×15(hr) = 1050 Wh
Total saving in a single room is = 2840Wh = 2.84 kWh
Total saving in all 18 single room is = 2840 (Wh) × 18 = 51120Wh = 51.12 kWh

Double room:-

Now we calculate energy saving in a double room.
T-6 tube light saving is 2×39(W) ×18(hr) = 1404 Wh
Ceiling fan saving is 1×40(W) ×20(hr) = 800 Wh
Table lamp saving is 2×48(W) ×6(hr) = 576 Wh
Table fans saving is 1×15(W) ×18(hr) = 270 Wh
Computer saving is 1×70(W) ×15(hr) = 1050 Wh
Total saving in a double room is = 4100 Wh = 4.1 kWh
Total saving in all 152 double room is = 4.1 (Wh) × 152 = 623200Wh = 623.2 kWh

Bathroom:

No of bathroom in the main buildings is six (6).

Total energy saving in these bathrooms is = 6× 2808 (Wh) = 16848Wh = 16.848 kWh
The daily energy saving caused by water pump is 200(W) × 5(h) = 1000Wh = 1 kWh

Corridor light:

There are almost thirty (30) 4 feet tube lights to illuminate the premise. The energy saving by replacing these lights is 30×39(W) ×10(hr) = 11700 Wh =11.7 kWh

The overall energy saving in main building is = (51.12 +623.2+16.848 +11.7 +1)kWh= 703.868 kWh

Mosque:

T-6 tube light saving is 20×39(W) ×5(hr) = 3900 Wh
Ceiling fan saving is 23×40(W) ×2(hr) = 1840 Wh
Total saving a mosque is = 5740Wh = 5.74 kWh

Provost office:

T-6 tube light saving is 23×39(W) ×9(hr) = 8073 Wh
Ceiling fan saving is 12×40(W) ×9(hr) = 4320 Wh
Computer saving is 2×70(W) ×9(hr) = 1260 Wh
Air conditioner saving is 1×100(W) ×5(hr) = 500 Wh
Total saving in a mosque is = 14153Wh = 14.153 kWh

Saloon:

T-6 tube light saving is 4×39(W) ×15(hr) = 2340 Wh
Ceiling fan saving is 2×40(W) ×15(hr) = 1200 Wh
Total saving of the saloon is = 3540 Wh = 3.54 kWh

Iron room:
T-6 tube light saving is 3×39(W) ×18(hr) = 2106 Wh
Ceiling fan saving is 2×40(W) ×15(hr) = 1200 Wh
Total saving of the iron room is = 3306 Wh = 3.306 kWh

Reading room:

T-6 tube light saving is 24×39(W) ×20(hr) = 18720 Wh
Ceiling fan saving is 18×40(W) ×20(hr) = 14400 Wh
Total saving of the iron room is = 33120 Wh = 33.12 kWh

Canteen:

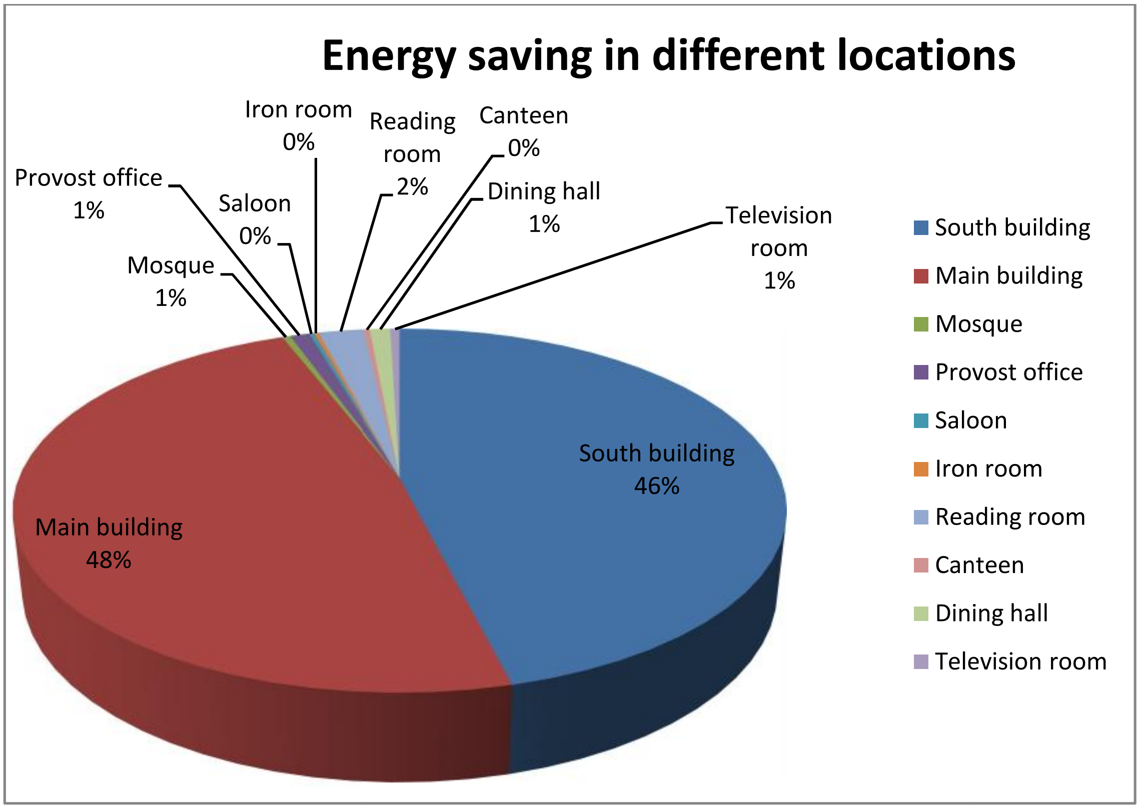
T-6 tube light saving is 7×39(W) ×9(hr) = 2457 Wh
Ceiling fan saving is 6×40(W) ×9(hr) = 2160 Wh
Total saving of the canteen is =4617 Wh = 4.617 kWh

Dining hall:
T-6 tube light saving is 24×39(W) ×9(hr) = 8424 Wh
Ceiling fan saving is 14×40(W) ×6(hr) = 3360 Wh
Refrigeration saving is 2×250(W) ×6(hr) = 3000 Wh
Total saving of the dining hall is =14784 Wh = 14.784 kWh

Television room:
T-6 tube light saving is 10×39(W) ×9(hr) = 3510 Wh
Ceiling fan saving is 10×40(W) ×8(hr) = 3200 Wh
Total saving of the television room is =6710 Wh = 6.71 kWh

Table -9: Overall energy saving of hall at different locations

Building name	Daily energy saving (kWh)
South building	674.584
Main building	703.868
Mosque	5.74
Provost office	14.153
Saloon	3.54
Iron room	3.306
Reading room	33.12
Canteen	4.617
Dining hall	14.784
Television room	6.71
Total	*1464.422*



Graph-5: Energy saving in different location in the hall

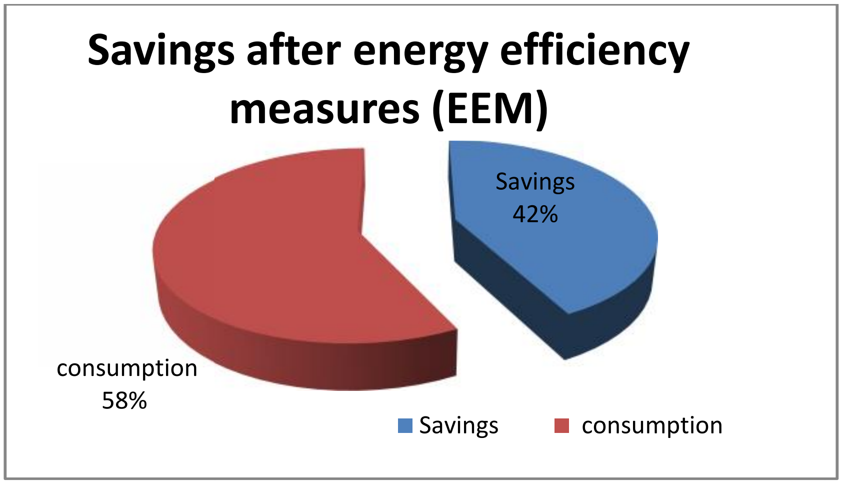
Annually the savings will be 534.51 MW-h

According to the flat rate fixed by utility service company like DPDC the savings by each day will be = (*1464.422*× 7.57) taka = 11,085.67 taka

Annual savings will be in taka is = 40,46,271.20/-

Table-10: Savings in terms of energy unit and electricity bill

Savings parameter	Daily	Monthly	Yearly
Energy unit	*1464.422 kWh*	*43.93 MWh*	*534.51 MWh*
Electricity bill	*11,085.67 taka*	*3,32,570.1 taka*	*40,46,271.2 taka*



Graph-6:Percentage of saving energy after taking EEM

Daily energy saving = (*1464.422*/*3441.84*)× 100% = 42.56 %

vi) Payback Period

The payback period (PBP) is the amount of time that is expected before an investment will be returned in the form of income. Payback period means the period of time that a project requires to recover the money invested in it. The payback period of a project is expressed in years and is computed using the following formula:

$$\text{Payback period} = \frac{\text{Investment required for a project}}{\text{Net annual cash inflow}}$$ ....(1)m

According to this method, the project that promises a quick recovery of initial investment is considered desirable. If the payback period of a project computed by the above formula is shorter than or equal to the management's maximum desired payback period, the project is accepted otherwise it is rejected.

Analyzing various types of electrical load there are 456 small table fans, 661 tube lights, 409 ceiling fans , 626 table lamps , 324 desktop computers used every day. If we replace these appliances by energy star rated appliances then we save more than 1200 kWh or 1200 unit of utility bill equivalent to 8500 taka per day.

Each energy efficiency small table fan cost 3000 taka. Total cost for replacing these fan will be = 456 ×3000 = 1368000/-

Each energy efficiency T-6 tube light cost 500 taka. Total cost for replacing these tube light will be = 700×500 = 350000/-

Each energy efficiency ceiling fan cost 3000 taka. Total cost for replacing these ceiling fan will be = 409×3000 = 12,27,000/-

If we replace each CRT monitor of a desktop computer by high efficiency LED monitor then it takes 7000 taka for replacing a single monitor. The total cost will be = 324×7000 = 22,68,000/-

Table lamp used in everyday life is incandescent 60w bulb. If we replace the bulb by high efficiency 12w LED light then there will be some cost. Each 12w LED light cost 300 taka. The total cost for 12W LED light will be = 650×300 = 1,95,000/-

There are six water pumps that used for supplying water will also replace by high efficiency motors. This will cost some money.

To install these equipments in the premises of hall we will have to hire technician and some auxiliary helping hands. It will cost some money. We also include that amount in this initial costing proportion. We'll give a contract to the technician at an amount of 10000 taka, so that his team will install all these equipments at shortest possible time then this installation will be in more professional way.

Total cost for converting energy efficiency hall is = (13,68,000+3,50,000+12,27,000+22,68,000+1,95,000+25,000) /- = 54,33,000/-

According to refinance scheme [9] of Bangladesh Bank, the interest rate is 9%. If we borrow the initial amount of investment from bank for two years, then we have to pay the sum of investment and interest. The interest of this 54,33,000/- will be 9,77,940/- or yearly 4,88,970 /-

The total amount that have to be paid is (54, 33,000+9, 77,940) taka = 64, 10,940 taka

Initial cash flow or the savings for a year is (11085.67 ×365) = 4046271.2 taka

So payback period will be calculated by equation (1)

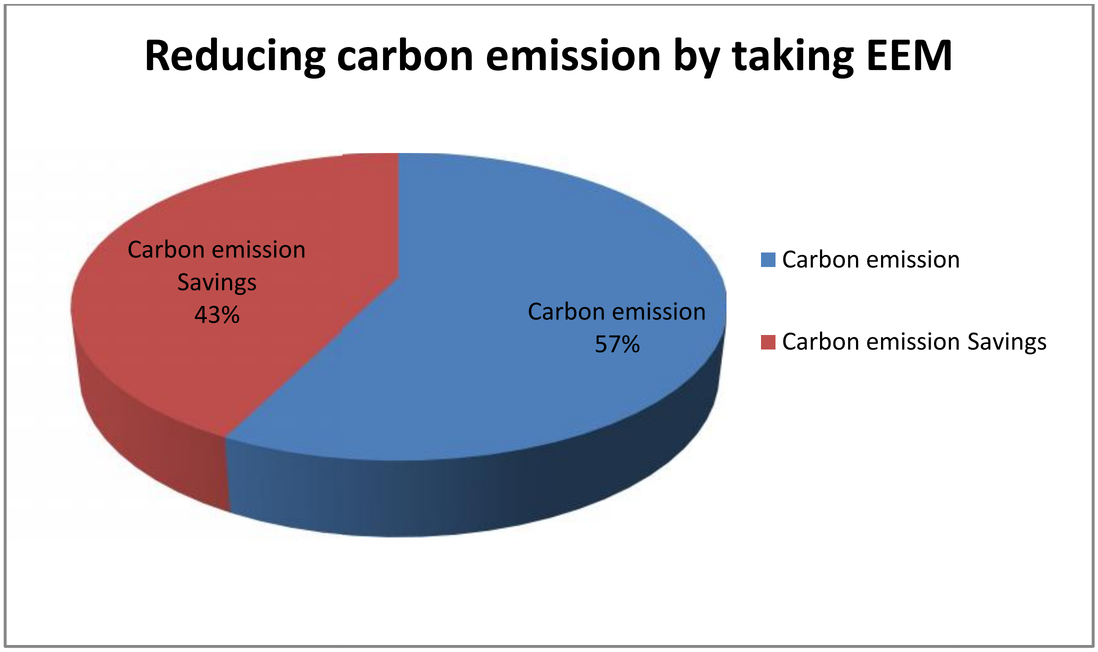
Payback period = (6410940 / 4046271.2) = 1.58 years

Table- 11: Cost analysis for implementing energy efficiency measures

Equipment cost (taka)	Installation cost (taka)	Interest rate	Interest for 2 years (taka)	Total cost for 2 years (taka)	Annual savings or cash inflow (taka)	Payback period (years)
54,33,000	*25,000*	*9%*	*9,77,940*	*64,10,940*	*40,46,271.2*	*1.58*

vii) Carbon Emission Reduction

The generation of electricity is mostly based on the burning and utilization of various fossil fuels in Bangladesh. From the present energy scenario we got a brief description on the usage of fossil fuel. To generate 1 MW-h of electrical energy we have to emit 0.67 tons of CO_2 to our environment. So the generation of 1255.76MW-hof electrical energy emits 841.362 ton of CO_2 annually. This amount of power is generated by burning a huge amount of fossil fuel like natural gas, farness oil, coal etc which cause carbon emission and pollute our environment.After the implementations of energy efficiency measures, annually we can fulfill our daily needs by 691.25 MW-h of electrical energy and save **534.51** MW-h of electrical energy.



Graph-7: Reduction of carbon Emission

The generation of 691.25 MW-h of electricity will cause emission of 463.1375 tons of CO_2 in our environment annually. Eventually we can reduce carbon emission about **358.12** ton of CO_2. Taking sufficient energy efficiency measures in the hall we can reduce more than 42.6 % of carbon emission. Bangladesh has only 12% land for natural forest whereas to keep our local environment clean and safe, we must need at least 25% of our land area under natural forestation.

CHAPTER - 4

RESULT

From loadanalysis, cost analysis and payback period calculation we get that there are some areas that consume a lot of electrical energy and these areas need some modification for getting energy efficiency measures. The most five energy consuming appliances are already indicated and if we will replace these five appliances then we can reduce almost 42.56% of our valuable electrical energy. If we use these types of energy efficiency measures we'll save a big amount of 534.5 MW-h of energy annually.

This cost will get back in just one and half years. Moreover the energy efficiency appliances that used in this modification will have a minimum warranty of two (2) years. That means we will save 1603.5 MW-h electrical energy which is equivalent to 1.2 crore taka. Moreover we can also reduce carbon emission by 43% annually.

Table- 12: Overall fieldwork and prediction at a glance

Peak electrical energy consumption	1051.11 kW-h
Off-peak electrical energy consumption	2390.338 kW-h
Daily electrical energy consumption	3441.84 kW-h
Yearly electrical energy consumption	1255.76 MW-h
Replacement cost	54,33,000 taka
Installation cost	25,000 taka
Interest for two years	9,77,940 taka
Total investment	64,10,940 taka
Daily electrical energy saving	1464.422 kW-h
Yearly electrical energy saving	534.51 MW-h
Energy savings percentage	42.56%
Reduction of carbon emission	358.12 ton
Reduction rate	43%
Monthly electrical bill saving	3,32,570.1 taka
Yearly electrical bill saving	40,46,271.2 taka
Payback period	1.58 years

CHAPTER - 5

CONCLUSION AND FUTURE WORK

On the basis of this thesis we get some viewpoints on the conservation and efficiency of electrical energy measures. The current government takes some crucial steps to generate more electricity than before. Following by the Power System Master Plan we have to generate about 25,000 MW which will eventually increase our economic growth, reduce digital divide by using safer, reliable electricity. If we practice energy efficiency measures more accurately in our everyday life we will save a lot of electricity. Furthermore the saving not only measures in terms of money but also increase the penetration rate of electricity.

According to the Perspective Plan -2021 to build a Digital Bangladesh the practice of energy efficiency program will lead us to middle income country. Proper training on electrical energy efficiency, development of sufficient technicians and manpower so that they can easily and reliably install energy efficiency devices, reducing the production cost of energy efficient components are some key factors that are still in very preliminary state. Our government will have to look on these factors.

If we encourage our manufacturers by direct financial incentive so that energy saving component can easily make in our country with a little cost. The implementation of various courses in different vocational training center will create a lot of well-trained technician will also help to increase energy efficiency. In surveying the field work we didn’t use sophisticated measuring instruments that measured various parameters more accurately and perfectly. Future researchers in this field will include these sophisticated measuring instruments for more accurate prediction.

CHAPTER - 6

BIBLIOGRAPHY

1. http://www.iea.org/topics/energyefficiency/
2. http://www.iaee.org/en/publications/newsletterdl.aspx?id=189
3. http://www.bpdb.gov.bd/download/PSMP/PSMP2010(Summary).pdf
4. http://www.cop21paris.org/about/cop21
5. http://www.wri.org/indc-definition
6. http://www4.unfccc.int/submissions/INDC/Published%20Documents/Bangladesh/1/INDC_2015_of_Bangladesh.pdf.
7. http://www.energystar.gov
8. https://www.desco.org.bd/index.php?page=tariff-rate
9. https://www.bb.org.bd/mediaroom/circulars/circulars.php
10. U.S. Energy Information Administration Glossary, http://www.eia.doe.gov (Accessed December 5, 2011)