Cost Effective Solar Study Lamp And Solar Home Solution for Non-Critical Application

A Thesis
Submitted to the Department of Electrical & Electronics Engineering,
BRAC University

By

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In Partial Fulfillment of the Requirements for the Bachelor of Science degree in Electrical & Electronics Engineering

Summer 2017

Declaration

This is to declare that this thesis titled “Application of solar energy for building portable solar LED study lamp” is submitted to the department of Electrical and Electronics Engineering of BRAC University for the partial fulfillment of the degree of Bachelor of Science in Electrical and Electronics Engineering. We hereby affirm that the theoretical research and result was conducted solely by us and has not been presented previously elsewhere for assessment. Materials of the study and work found by other researchers have been properly referred and acknowledged.

Submission Date: 20th August, 2017

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Abstract

Over half a billion children is suffering from lack of adequate lighting and they rely on dim, smoky, and dangerous kerosene-based lighting for their evening studies. This paper is on how we can provide our rural students a brighter, clean, safe, and zero-marginal-cost light of solar lamps enhances children's learning outcomes. The solar lamp can provide continuous light of 150 lux for studying properly around 5 to 6 hours; this may be due to flickering from lack of full charge that lowered their productivity. These solar lamps likely have insignificant effect on educational attainment. We also have built an android phone application on solar home system that can calculate critical applications of solar home system which can provide inverter selection, how much battery and PV module required in series and parallel information to the user, basically we named it solar calculator for the user.

Acknowledgements

First and foremost we are very thankful to our God for providing us with the patience and strength to go on and complete this thesis.

We are grateful to our supervisor Ms. Marzia Alam, Senior Lecturer of BRAC University for her utmost support as well as critical comments and extensive guidelines. Her invaluable guidance, excellent research attitude and knowledge about the field of study always encouraged us.

Lastly we offer our regards and gratitude towards all of our family members and those who supported us from the beginning in any aspect during the completion of this thesis project

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List of Abbreviations

1. **1REB-Rural Electrification Board Bangladesh**
2. **BANBIES-Bangladesh Bureau of Educational Information and Statistics**
3. **GER-Gross enrollment rate**
4. **NER- Net enrollment rate**
5. **HIES-Household Income & Expenditure Survey**
6. **PH-Peak Hour**
7. **PV CELL- Photovoltaic Cell**
8. **SOP - Small outline packages**
9. **LED – Light Emitting Diode**
10. **PV – Photovoltaic**
11. **PTC – Positive Temperature coefficient**
12. **SSL -Solid State Lighting**
13. **GDP – Gross Domestic Product**
14. **CPD – Central for policy Dialogue**
15. **JICA – Japan International Corporation Agency**
16. **GER – Gross Enrollment Rate**
17. **NER – Net Enrollment Rate**
18. **p-Si – Polycrystalline**
19. **PTC – Positive Temperature Coefficient**
20. **Lipo Battery – Lithium Polymer battery**

21. SSL – Solid State Lighting

22. FC- Foot-candles

23. AC - Alternate Current

24. DC – Direct Current

25. PH – Peak Sunshine hour

Lists of Units

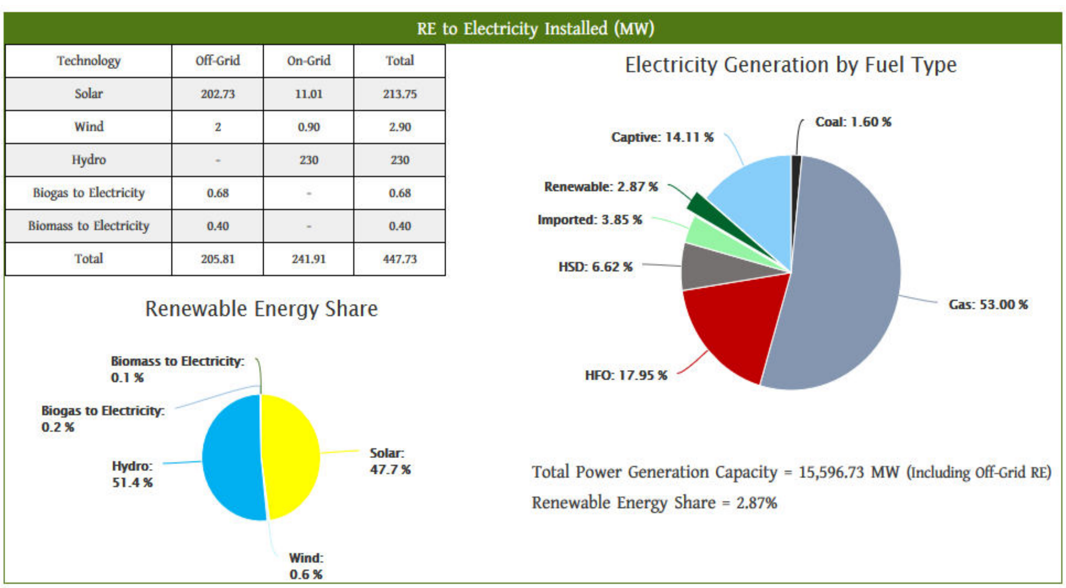
1. Lux
2. Lumen
3. Watt
4. Celsius
5. m AH
6. Ohm
7. Amp
8. Watt/ hour
9. MW

Chapter 1

Introduction

1.1 Background Story

After the birth of Bangladesh through liberation war in 1971, it seems always have progressive development with the growing economy. The demand for electrical energy has increased significantly with the passage of time to meet the challenge of the twenty first century for continuing developing process smoothly. Bangladesh mainly dependent on fossil based electricity .Since fossil fuels are non-renewable and require finite resources which are declining because of environmentally damaging retrieval technique. Due to such concern, developing countries like Bangladesh are facing setbacks in sustainable development. 60 percent of country's total population is connected to national power grid and the rest is living in the off grid region. As the national grid does not have the capacity to extend to those regions a significant number of households are generating power from solar energy. The following figure shows the fuel based electricity and renewable energy capacity installed by Bangladesh rural electrification board **[11]**



Technology	Off-Grid	On-Grid	Total
Solar	202.73	11.01	213.75
Wind	2	0.90	2.90
Hydro	-	230	230
Biogas to Electricity	0.68	-	0.68
Biomass to Electricity	0.40	-	0.40
Total	205.81	241.91	447.73

Fig1.1: RE to Electricity installed

Bangladesh receives 5KWh/m2 solar radiation on an average every day for 300 days per year. The total solar energy reaching Bangladesh is 180*109 Mwhr/year which is 105 times the energy generated as electricity in our country. If we can utilize even the 10 percent of the solar energy Bangladesh receives, providing electricity to the entire population of our country will be feasible in the near future. Every epic journey starts with small step; utilizing solar energy can be a great initiative for Bangladesh towards the path of achieving clean and sustainable energy.

Sustainable & Renewable Energy Development Authority

Renewable Energy/Energy Efficiency Status Report (Installed)

Year	Solar Home System (Number & MW)	Solar Irrigation (Number & MW)	Solar Water Heater (Number)	Solar Drinking Water System (Number & MW)	Biogas Plant (Number)	Improved Cook Stove (Number)	Improved Rice Parboiling System (Number)	Conversion of simple cycle to combined cycle power plant (Number)	Co-generation (Number)	Energy Saved (toe)
2017	13094 0.54 MW	18 0.21 MW	-	-	1552 -	239150 -	-	-	-	-
2016	251720 10.03 MW	342 3.40 MW	-	32 0.15 MW	4292 -	1.3 million -	7 -	-	-	-
2015	588883 25.56 MW	171 1.70 MW	-	60 0.70 MW	4829 -	839061 -	-	-	-	-
2014	907835 33.31 MW	71 0.64 MW	-	60 0.70 MW	5152 -	507453 -	68 -	-	-	-
2013	800000 34.00 MW	37 0.33 MW	-	-	7587 -	428000 -	-	-	-	0.96
2012	715250 26.83 MW	52 0.34 MW	-	-	5369 -	-	-	-	-	-
2011	1.2 million 49.00 MW	0 -	-	-	20641 -	-	-	-	-	-
2004	-	-	-	-	21974 -	-	-	-	-	7.56
2001	-	-	-	-	-	117573 -	-	-	-	-
Total	**4.5 million 179.27 MW**	**691 6.62 MW**	**-**	**152 1.55 MW**	**71396 -**	**3.4 million -**	**75 -**	**-**	**-**	**8.52**

Fig 1.2: Renewable energy report status Installed

1.2 Motivation

Education is one of the fundamental right for the students but Bangladesh is still lagging behind to meet the challenge of total electricity required a day besides there are so many rural areas and regions where electricity is not reached and available yet. We were motivated to build a solar study lamp which will meet the minimum demand of lightening to study for at least 4 to 5 hours without any interruption. With a very low cost price and with long durability it will help the school going children in their daily studies.

Solar energy is totally clean and renewable and doesn't emit carbon dioxide during its operation. Solar energy is a renewable energy resource that does not generate pollution and has become an increasingly valuable way to diversify the nation's energy options. Spurred by technological advances, falling costs, and rising energy prices, solar energy projects are being developed across the country and being so popular among the rural people. .According to Heinrich Hertz the photovoltaic effect is the phenomena in which electrons at the surface of any matter are emitted by absorbing energy from electromagnetic radiation such as visible light. A material used in photovoltaic effect (PV) known as PV cell, which are generally made by silicon semiconductor device. In PV cell, when sunlight strikes on the surface of PV cell it absorbed solar energy and if absorbed energy is greater than the band gap energy of the semiconductor, the electron from valence band jumps to the conduction band, Which is responsible for solar current.

The major material of photovoltaic panel which is the most commonly used today is silicon, it is a semiconductor device with a positive temperature coefficient i.e. increase in temperature results in increase in resistance and power loss which decreases the efficiency of photovoltaic panel. So for proper operation solar panel should be operating within the reasonable temperature limit. The efficiency of PV system can be increases by using a suitable Maximum power point tracker (MPPT) device that provides a maximum current and voltage to the inverter circuit which enhance the efficiency of PV system. Based on this solar PV system we were motivated to build a cost efficient solar based led light lamp which provides minimum 150 lux of light.

Lighting has important effect upon health and productivity which influence the performance of the student. Good lighting plays an important role in their daily studies to achieve success as it encourages them to give their best performance.

Poor lighting discourages them and it slow down their performance. Besides it's injurious to health as well. LED or light emitting diode is nowadays very popular and commonly used for lightening system. The use of LED technology in general lighting system is a good option because of its continuous improvements and advantages, including long lifetime, low power cost, the physiological impact to the user, low light pollution and low carbon footprints. According to the study, a LED circuit will approach 80% efficiency, which means 80% of the electrical energy is converted to light energy and the remaining 20% is lost as heat energy. Comparing with incandescent bulbs which operate at 20% efficiency (80% of the electrical energy is lost as heat). LEDs can emit a larger amount of light intensity than any other lamps. Gradually, other lamps experience a gradual reduction in their light output. The more it is used the more it fails to maintain its light output. LEDs do not fall to under this category of lamps thus; it will still give a good measure of light intensity.

So with combination of solar energy and LED; our goal is to make a solar study lamp and testing the performance and to make improvement of life cycle of the lamp in Bangladeshi perspective. A solar study lamp is a lightening device consists of a PV module, battery, LED light, and electronics. The solar study lamp is especially suitable for study purpose.

1.3 Objective

The aim of this thesis is to investigate fundamental science and technological aspects of generating a cost efficient solar study lamp which will focus on:

1. Reliability
2. Efficiency
3. Costing
4. Testing performance

1.4 Thesis Organization

Chapter 1

This introductory chapter provides background information about the overall scenario of Bangladesh and its electricity capacity and determining the problem. It also includes background to the present research work, describes the objectives and outline of the thesis.

Chapter 2

This second chapter gives an overview of the existing lightening sources and information about the off grid network area of Bangladesh and also focuses on the minimum amount of lightening for study purposes. It will also discuss about the students and their current condition in education system.

Chapter 3

The third chapter outlines the field test and survey of a sample village and provides the data and necessary information to set the requirement for building the solar lamp and setting some guideline with proper demand of the customer.

Chapter 4

This chapter explains the necessary components and methods of developing the multipurpose solar study lamp. Also explains the architecture of the solar study lamp.

Chapter 5

In this chapter, different performances testing results and data have been discussed. Besides we calculated overall coast of the product of a single unit.

Chapter 6

In this chapter we have discussed about a solar calculator android app, for calculating required PV panel, Inverter, Battery capacity with built in function. We have named the app as solar calculator.

Chapter 7

This chapter summarizes the whole thesis project and talks about the scope of working. Despite that it also describes some ideas about future progression.

Chapter 2

An Observation on Electricity Crisis in Rural Bangladesh and Finding Solution

2.1 Electricity Crisis in Bangladesh:

In Bangladesh, the demand-supply gap of electricity is one of the largest problems for economic growth. The capacity of power supply facilities is only around 4,000 MW compared to the peak electricity demand of 6,100 MW, they have no choice but to have scheduled load-shedding of electricity supply during the peak time (JICA, 2010). Bangladesh is losing at least 3.5% of Gross Domestic product (GDP) due to the shortage of Power supply according to a research report of Centre for Policy Dialogue (CPD). In rural areas the condition is more serious. During summer times it gets worse. In rural areas people hardly get electricity during summer time. The key findings are given below:

- 80 Million People do not have access to electricity
- Rest 60 Million are getting unreliable power
- Load shed up to 1500 MW during hot summer days
- Installed Capacity:5450 MW (Jan 01, 2009)

Here we have tried to find out the most commonly used lamps by rural area people in Bangladesh. The following table shows the comparison:

Lighting Sources	Typical upfront Cost (Taka)	Lighting Services (Lumen)	Duration of Services (Hours)	Requires Technical Maintenance	Typical product Warranty
Hurricane Lamp 	200(Body) Kerosene oil (65 Taka Per Liter)	120-180	3-4	Yes	NO
Candle Light 	15	80-90	2	No	No
Smart Lamp 	600-800	230-250	4-5	Yes	No
Local Light (Without source) 	50	230-250	3-4	No	No

Table 2.1 Existing Lighting Source in Rural Bangladesh:

2.2 Lighting System in Rural Areas in Bangladesh:

In rural Bangladesh most of the people use local lamp as lighting sources for their daily household works. They mostly use Hurricane lamp, candle , or local made lamps which are not durable and does not give proper light requires for study or doing household works. Besides they have serious effects on health as well and there are always fire risks. So lightening is always a big problem for the rural people.

2.3 A Common Problem for Students:

Most of the students face problems in their daily studies at night time due to insufficient lighting a minimum 150 lumens. As a result their performance decreases and they lag behind and they lose interest in their studies. Besides there are many isolated areas in Bangladesh where electricity is still beyond reach or hardly finds.

2.4 Solar Technology as an Alternate:

Bangladesh is such a country which receives substantial radiation most of the time of the year, which can be the solution for our problem in the case. Solar powered lamp can be used anywhere where is sunlight. If we build a portable one that can be moved anywhere also. Besides this lamp can be charged during daylight and can be used all time when needed. That’s because it is solar based it has no pollution effect as it uses clean energy. There are no fire risks and health issues.

Bangladesh is located between 20**0**30’ and 26**0**45’ north latitude and the climate is tropical with adequate solar radiation. Nearly 75% of the population lives in rural areas and only about 30% of the rural households have access to grid electricity.

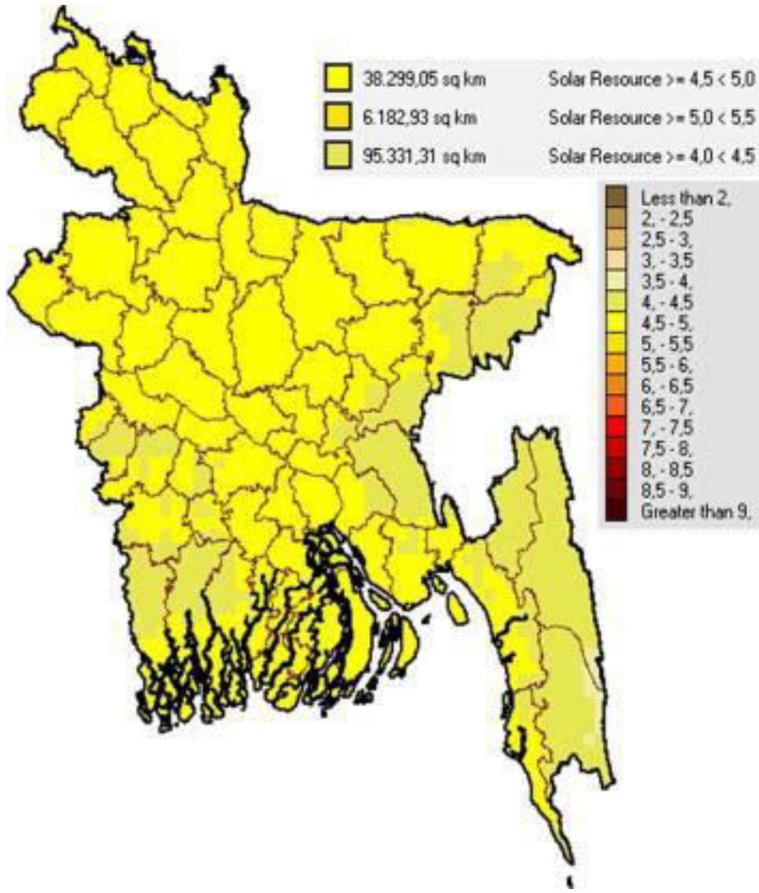


Fig 2.1 Solar radiation and area of Bangladesh with highest potential for solar energy utilization

2.5 Problem Statement for Thesis Project:

Our goal in this thesis project is to build a solar based study lamp which will give us minimum amount of lightening and with the features of durability, efficiency and gives the best performance with a very low cost than the existing in local market as they are very expensive.

2.6 Research Methodology:

The research project can be divided into two parts firstly is field survey to understand the real scenario of customer demand and responses and secondly the building of solar study lamp that meets our all goals and demands.

First we will do a survey in a sample village in rural Bangladesh to find our goal what people and students want to do with the solar lamp, how many hours they need to operate, their expected cost and additional features.

Secondly we are going to build our solar lamp with low coast and best performance, which will have durability and best efficiency to enlighten the rural areas to facilitate education.

Chapter 3

Research and Field Survey

3.1 Research Methodology

3.1.1 Aims and Objectives of Solar Study Lamp Survey:

The aims of the survey are -

a. To collect up to date quality data to determine sources of their house lighting, the number of their family members to achieve the number of school going children because the targeted group is these group of children.

b. To enrich hour skill of the professional in respect of conducting the surveys, monitoring, evaluation and research.

c. To determine the satisfaction of their costing for their house lighting, to understand their financial situation if they could afford solar study lamp or could cost on it according to their demand, also if they have face any trouble with lighting sources.

d. To let them know about solar study lamp and its advantages to their mind.

e. To understand their actual preferences directly refer to solar study lamp.

3.1.2 Specific Objectives of the Survey:

Specific objectives are-

a. Lighting sources
b. Desire
c. Availability
d. Needs
e. User preferences

3.2 Solar Lamps User Survey

3.2.1 Acceptance Sampling:

In the solar lamp user survey in Rajshahi, a sum of 30 lamp users had been interviewed. Among them, we have found that 27.77% were using candles, 25% were using charger light, 30.55 % were using torch light, 8.33% were using kerosene lamp(some people call it ‘Cherag’), 8.33% were using Hurricane for lighting their house. Besides that, most of the houses have the electricity provided by REB but they need to use these lighting sources as the load shedding occurs very frequently.

During the survey, we have also taken care of the number of family members of each family so that we could assume the number of children whom we target to use solar study lamp for a obstacle free study time. The average size of households have interviewed for the survey was 3.06 members ranging over all aged members, the average number of children below 16 in these households was 1.26 and the average number of adult men and women was almost equal.

3.1.2 Housing Structure:

The rural area of Rajshahi has been changed a lot with the progresses of time. There were only a few household dwellings which were built of mud. The maximum houses were made of burnt bricks or cement houses. About 20% of the houses were roofed with straw and 60% with the iron sheets.

According to Bangladesh Bureau of Statistics-Government of the People's Republic of Bangladesh, it is revealed from the table that, the highest 41.89% of household lived in katcha, durable housing structure with the wall and roof are made of tin/CI sheet. The percentage of houses with katcha non-durable materials accounts for 34.18% where roof are made of CI sheet/wood and wall is made of non-durable material like jute stalks/straw Etc. It is observed from the table that 9.47% housing structure were jhupri made of temporary materialslike sack, polythene, straw etc. (From recent publication of HIES,2016**)[12].**

Table 3.1: Type of Dwelling Unit of Head of Household and Size of Land Owned in Rural Area, 2010

Size of Own Land (Acre)	Type of Dwelling Units (Where head of the household residence)					
	Total	Pucca	Semi-Pucca	Katcha-Durable	Katcha non-durable	Jhupri/ Katcha temporary
1	2	3	4	5	6	7
Total	100	3.65	10.80	41.89	34.18	9.47
Landless	4.59	0.11	0.38	1.28	1.91	0.90
0.01-0.49	60.50	1.59	4.55	25.38	22.76	6.22
0.50-0.99	11.62	0.42	1.25	5.56	3.48	0.91
1.00-2.49	14.60	0.80	2.59	6.39	3.82	1.01
2.50-7.49	7.59	0.60	1.76	2.92	1.95	0.36
7.50+	1.11	0.13	0.29	0.36	0.26	0.07

3.1.3 Education, Occupation and Income:

Now days, access to education has increased. Literacy rate of population aged 7 years and over stands at 57.91 percent at national level, compared with 51.9 percent in 2005 respectively. In rural area, literacy rate in 2010 was 53.37 percent, compared with 46.7 percent in 2005 accordingly. In urban area, literacy rate was 70.38 percent in 2010, compared with 67.6 percent in 2005 while in 2010, enrolment rate of children aged 6-10 years for both sexes at the national level was 84.75 percent compared with 80.38 percent in 2005**[13].**

Some of households in the sample cultivate at least a small patch of land, usually around their houses, to grow food, often only for their own consumption. Agriculture is either a primary or a secondary occupation for 30% interviewed households.

A few of the households' state that their children under 16 helps in the family's agriculture or business, but it can be assumed that the rate of children helping with financial work is much higher than it seems. When respondents were asked whether the children also helped in agriculture or, business, the answer was usually

"Yes" where the large majority (91 %) of households with children below 16 states that their children go to school.

However, randomly we have asked the school going children who many times absent in the school why they have to absent sometimes and they answered in a way that most of the time they could not complete their homework due to lacks of light or, load shedding and they afraid of going school without homework. So, according to BANBIES report of 2016, the number of absent students are increasing day by day though the pass rate is remarkably high **[14].** Some online portal suggests that survey statistics of non-governmental the rate of all of these of governmental is much higher **[15].**

Year	Number of students participated	Absent	Pass Rate (%)	
			Total	Girls
2009	1979895	156,430	88.84	87.51
2010	2156721	216390	92.34	91.98
2011	2316521	130774	97.30	97.08
2012	2481119	160784	97.35	97.19
2013	2519032	120013	98.58	98.52
2014	2683781	105482	97.93	98.54
2015	2839238	111526	98.52	98.58

Note: Madrasha students Figure not included in this table

Table 3.2: Yearly number of students participated and absent chart.

Moreover, the enrolment rate of primary school is increasing day by day but the dropout rate is not decreasing compare to enrolment rate. However, the dropout rate is higher in level-4 than others **[6].**

Year	GER (%)			NER (%)		
	Boys	Girls	Total	Boys	Girls	Total
2005	91.2	96.2	93.7	84.6	90.1	87.2
2006	92.9	103	97.7	87.6	94.5	90.9
2007	93.4	104.6	98.8	87.8	94.7	91.1
2008	92.8	102.9	97.6	87.9	90.4	90.8
2009	100.1	107.1	103.5	89.1	99.1	93.9
2010	103.2	112.4	107.7	92.2	97.6	94.8
2011	97.5	105.6	101.5	92.7	97.3	94.9
2012	101.3	107.6	104.4	95.4	98.1	96.7
2013	106.8	110.5	108.6	96.2	98.4	97.3
2014	104.6	112.3	108.4	96.6	98.8	97.7
2015	105	113.4	109.2	97.1	98.8	97.7
2016	109.3	115	112.1	97.01	98.8	97.96

Source- DPE (APSC 2016)

Table 3.3: Enrolment rate in primary education, 2005-2016 (BANBIES)

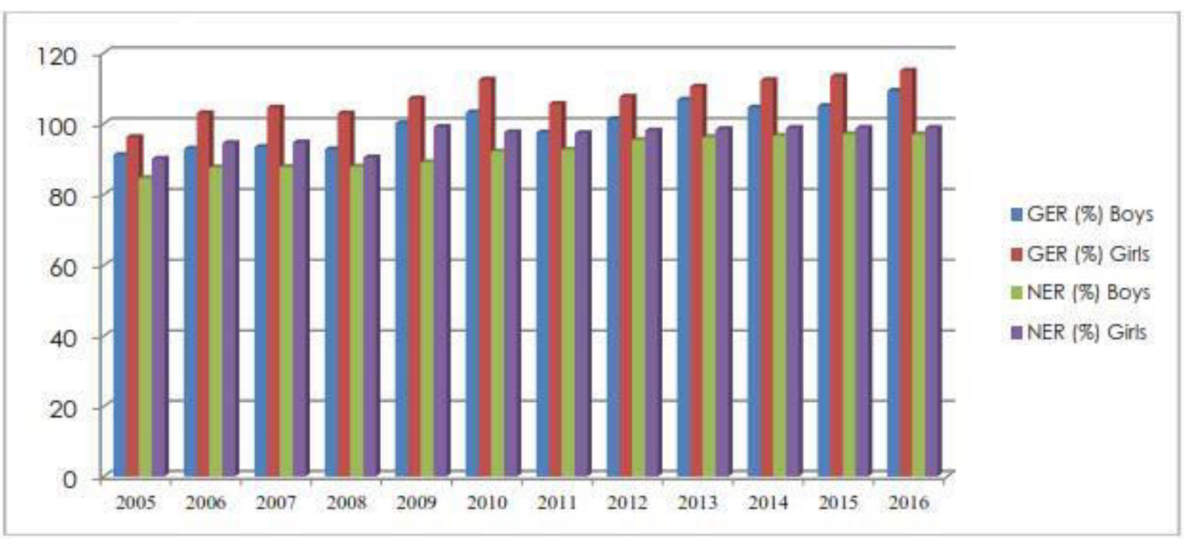


Figure 3.1: Primary Education Gross Enrolment Rate & Net Enrolment Rate 2005-2016

Sex	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Boys	0.5	4.4	6.0	10.5	1.1
Girls	1.0	1.3	2.6	9.1	1.7
All	0.7	2.9	4.2	9.8	1.5

Table 3.4: Dropout Rate (%) by Grade, 2016

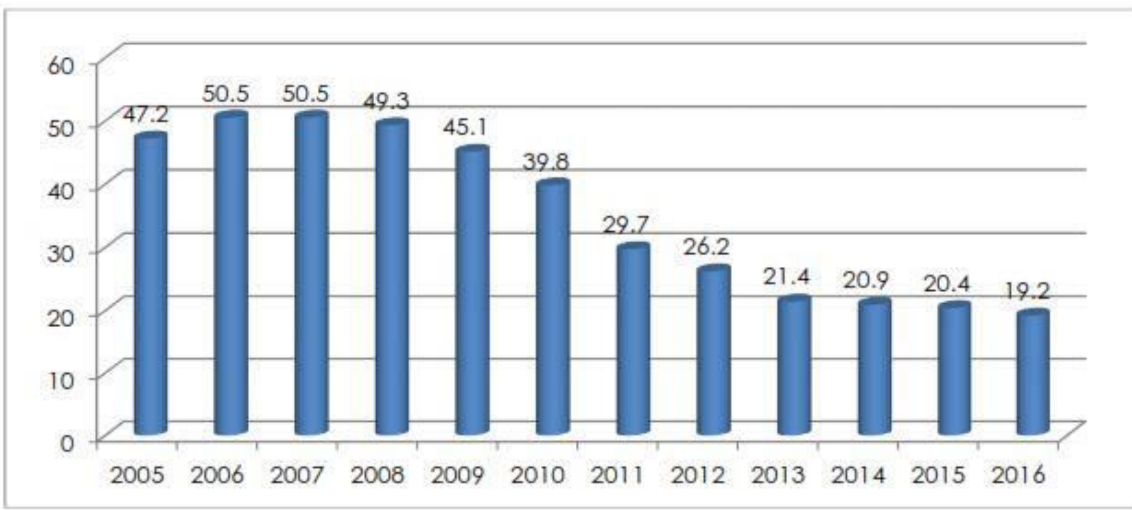


Figure 3.2: Year Wise Dropout Rate (%) 2005-2016

However, occupation of small village Maria of Rajshahi is different. The survey concluded with a decision that the most of the people are involving small business like raw materials, fishery grocery and driving profession. So, we have made a chart of it.

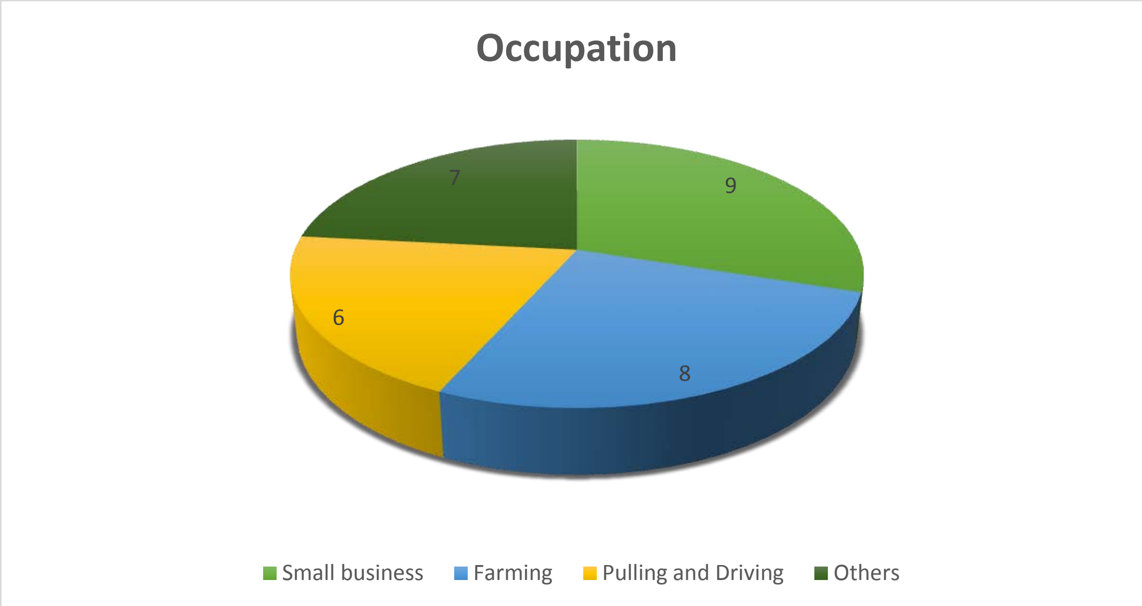


Figure 3.3 : occupation variety of maria village

However, the average monthly income of the interviewed people is BDT 5,400 tk. Many of these household women have not known that their husband's income. Even sometimes the maximum income depends on Eid or any other ceremony month as their business run more smoothly than any other month.

3.1.3 Energy Supply and Consumption:

In recent years, the grid extends in Rajshahi city though there is no larger industry in the city. However, the easy bike is becoming very popular in recent years. The easy bike needs to be charged every day. Many of the local people take the 440v DC line to take a business opportunity in the city. Though there is no large industrial factory, the people have to face load shedding almost every day. The average interviewed persons have been claiming that after every 4-5 days also.

The matter of consumption, almost every house has the electricity line but it is like no electricity connection because the load shedding is occurred very frequently. First time when they know about our solar study lamp, they seem very excited as they believe there is no need to depend on electricity which is full of load shedding, they also believe this lamp will provide more light and environment friendly. We have also asked without study where they want to use this lamp, they have said that they want to use the lamp in cooking, taking dinner, using latrine and many more.

3.1.4 Household Lighting Economics and Lighting Behavior:

At the time of the baseline interview in the village, people lit a lamp in the evening at 7 p.m. on average and switched off the last light at 10.30 p.m. if there is no electricity available in their house. The average lighting duration in the evening was 3 hours and 30 minutes actually. Even, one thirds of the households use a light also in the morning, mostly between 5:30 a.m. and 6:30 a.m. The average morning lighting duration was 1 hour.

Candles were the most important lighting energy source for households in the survey, used by 90% of households until now. More than half of the respondents named candles as the second most important energy source in their sourcing list. The average monthly house hold consumption of candles for lighting was 230.33 tk.

Based on availability and cheaper lighting sources they are preferred most. Moreover, they also find for easier to use sources. They have also mentioned that the sources like kerosene lamps and candles are not environment friendly and lacks of safety they have experienced. Besides that, charger light is cheaper but they have claimed that the charger is not the long lasting one though it is more preferable than others.

3.1.5 Priority Needs to Improve Living Condition:

During the solar study lamp survey, people around the village were very much excited and hopeful hearing about something new lamp that can be used whenever they wish. So, it is quite clear that people in rural area have been suffering from better lighting for many days to improve their living condition.

However, the main reason why people wanted to improve the lighting situation in their houses we assume was that they felt they were hampered in doing certain activities at night including children's study. Besides that, lack of security or risk of accidents was their next most important inconveniences.

Additionally many of households reported that there had been accidents in their houses associated with the use of lighting devices such as kerosene lamps or candles. They had added that accidents occurred as someone cut themselves on broken glass from a hurricane lamp or, burns or objects by catching fire.

Whatever, we have also asked them in which way they want to use the solar study lamp and we have found that most important and prioritized is study of the student member of the family. So we can conclude with that studying is hampered most for the lacks of lighting.

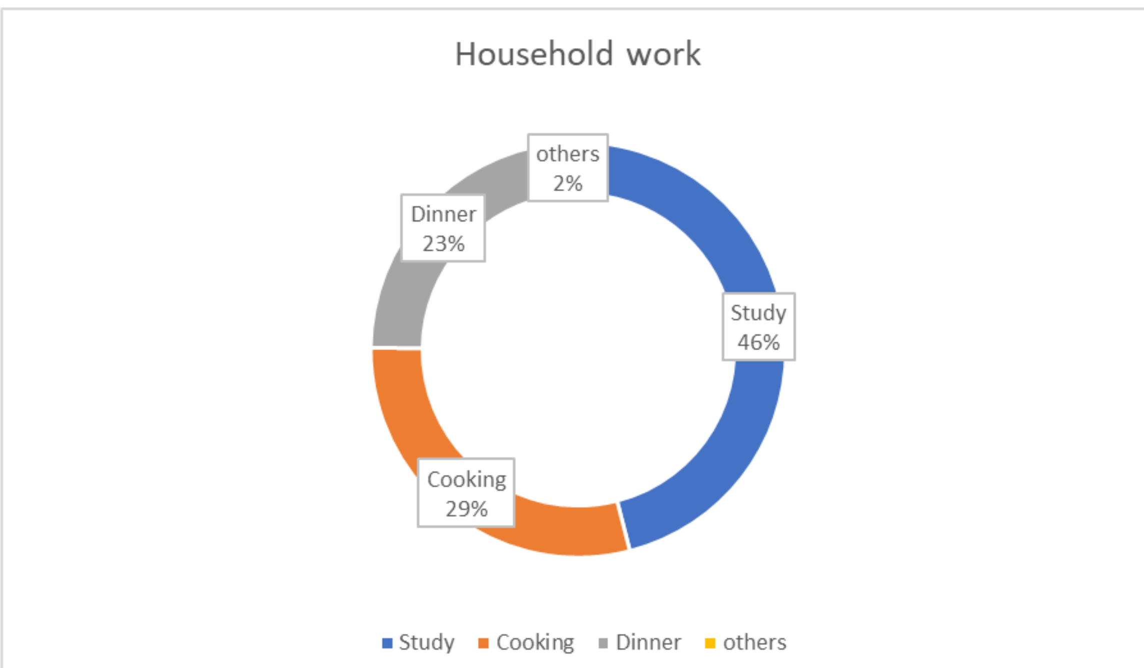


Fig 3.4: which one is hampered most due to lack of lighting in the evening?

3.2 Solar Lamps Field Test

3.2.1 Which Lamp Model Do Users Prefer?

Quality is unanimously regarded as they always prefer having the best lighting source within their ability. Several focus group members could comment on the low quality of Chinese products and believe that the place of manufacturing is a factor that they take into consideration when making purchasing decisions. When products relabeled as “made in Germany”, people state that they expect them to be of high quality, while they normally avoid buying Chinese products in fear of short life periods.

Moreover, the focus group results as well as having the interview to a strong preference for multi-purpose lamps with luminance levels which are sufficient to light almost a room. People want a lamp that is useful for all family members to pursue their evening activities also. But apart from that the lamp should be suited for reading and studying, ideally for more than one student at a time.

Normally, people appreciated a lamp design that represents the traditional charger light that can be used in the same manner like “exactly like the one we use”. They have also talked about a solid design lamp and smooth lighting with minimum 7 months warranty. In case of warranty we have asked which part, they need to be guaranteed and simply their answer was the battery. Interestingly, at the end they have shown their interest at lower pricing and if locally the lamp is available, most of the people wish to buy it as their belief is that it would provide them with sufficient light.

3.2.2 How Do Lamps Perform Under Real-Life Conditions?

The performance of solar lamp in real life observation seems a little bit difficult for us as we could not provide the lamp to the targeted people for using. The reason behind that is sponsorship because we could not afford to provide required solar lamps to the village we surveyed. So, we had tested it in our own resident. We also have tried to take the data from different places such as Mohakhali, Azimpur, Mirpur and Savar to gather different experiences of this project to reach a closely satisfied conclusion.

First of all, before doing this project we thought that, the cloudy days could not supply proper sun rays that a solar panel worked, but we have seen that that is not true, even the panel provides about 30 to 40 percent of its rated specifications.

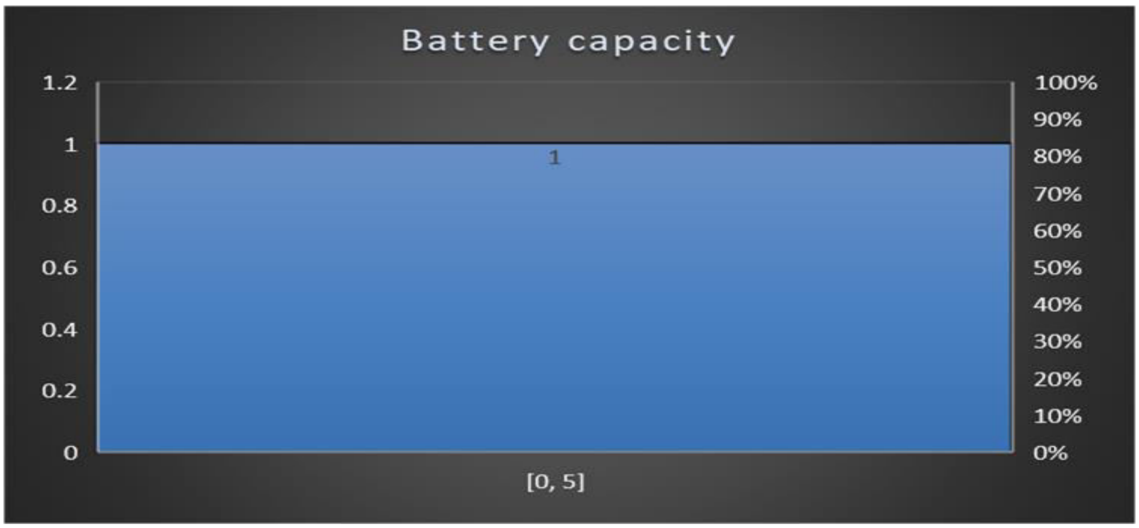


Fig 3.4: Battery voltage operating at 80%

The intensity of the solar study lamp we have also measured on average of 150 lux/meter square. The light is satisfactory for reading purpose; 2-3 children can read using this lamp also.

Fig 3.5: solar lamp with light measuring in Lux

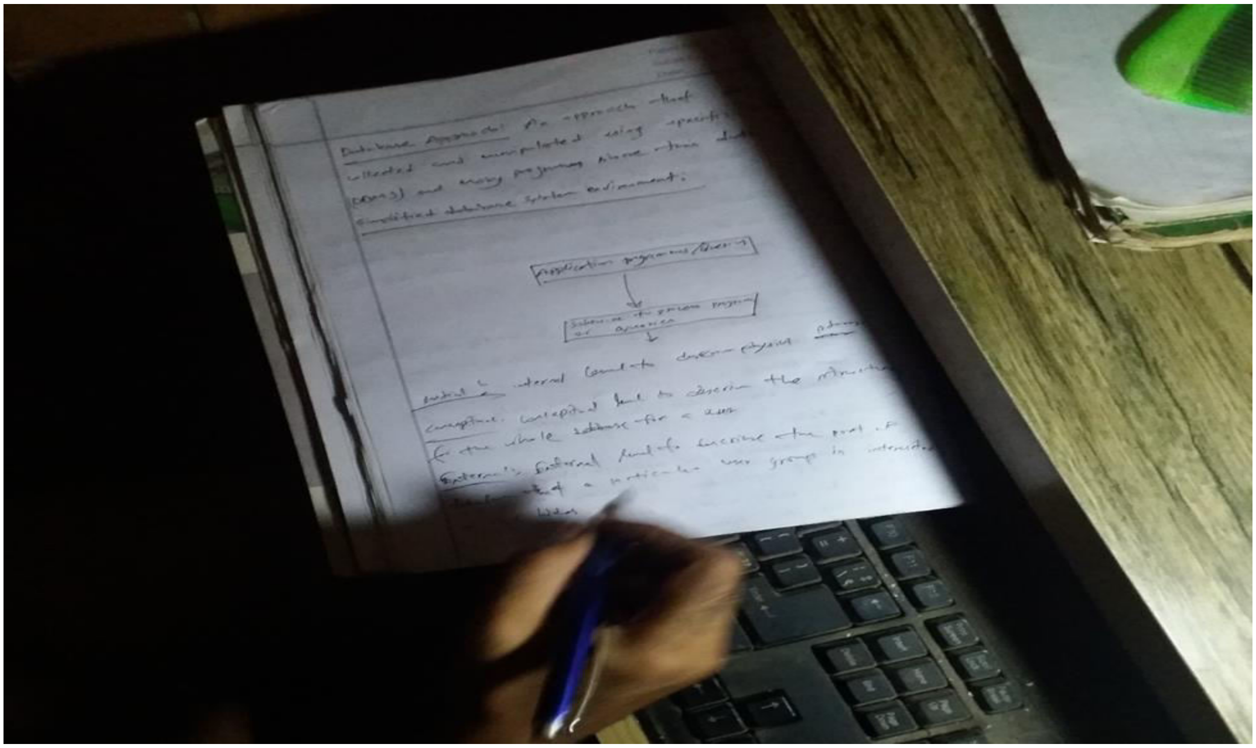


Fig 3.6: Solar lamp reading condition at night

3.2.3 How much are Customers willing to pay for a Solar Lamp?

Whatever, we have also asked for how much they are expecting the price of solar study lamp during the interview. The average cost we found that 50% of surveyed people will definitely buy the solar study lamp if the lamp is locally available and the average cost is ranging from 210-420 tk. They have also preferred for longevity of whole instruments at least for 6 months.

However, we have worked on to fix up minimum price of the solar study lamp. We have found that if the casing of solar study lamp can reduce and obviously it will reduce if commercially we ordered about 100 piece.

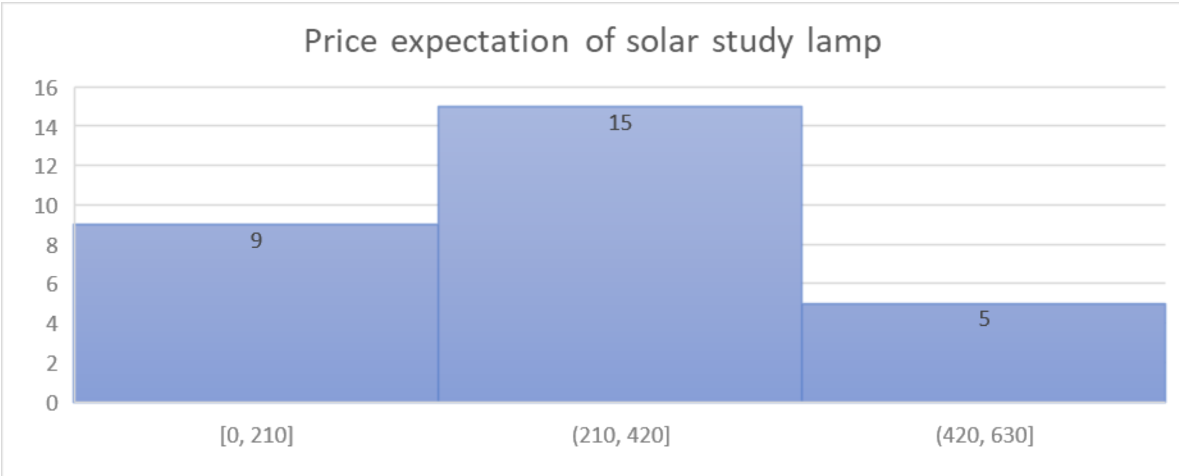


Fig 3.8: Price expectation of solar study lamp

So from our field survey and research we have estimated the product of a single unit and that is about **680tk.**

Chapter 4

Architecture of Solar Study Lamp

4.1 General Overview of the System:

The solar study lamp is not a single piece of hardware but several electronic devices connected to each other. The very design of separate individual components connected together allows us to add more parts according to our need. When we talk about connecting different blocks of electronic components to each other it is not simple connection at all. The main component blocks are-

- Solar Panel
- TP4056 Module
- Battery
- High Power LED
- Battery Level Indicator

4.2 Understanding Tasks and Our Approach:

Here we are trying to make a lamp which is perfect for study at night which will be charger by a solar panel which will charge lithium Ferro phosphate battery is connected with the panel through a module named TP 4056 module which ideally suited for portable applications. The TP4056 can work within USB and wall adapter. Here no blocking diode is required due to the internal PMOSFET architecture and have to prevent negative Charge Current Circuit. By charging the battery we can use the LED light as a study lamp at night. An indicator is included there to identify the battery percentage.

4.3 Solar Panel

4.3.1 Background

Photovoltaic (PV) system is a highly competitive technology to convert the incident solar power into electrical energy. Pursuing high efficiency is always the important task for PV technology. However it is still a long way from being competitive with fossil fuel based energy conversion technologies. A major issue is there the limited efficiency of solar energy conversation. Where electricity is still unreached there solar panel energy is mostly important and can play an important role.

4.3.2 Photovoltaic Cell

Photovoltaic cell is a semiconductor device that converts photons into electrical energy by photovoltaic effect. The term “photo” means light and “voltaic” means electricity. When sunlight strikes on a PV cell, the photons of the absorbed sunlight dislodge the electrons from the atoms of the cell. The free electrons then move through the cell, creating and filling in holes in the cell. It is this movement of electrons and holes that generates electricity. The physical process in which a PV cell converts sunlight into electricity is known as the photovoltaic effect. We used in our project Polycrystalline solar panels because it is

- Simpler and cost less.
- The amount of waste silicon is less compared to others
- Polycrystalline solar panels tend to have slightly lower heat tolerance
- This technically means that they perform slightly worse

However, this effect is minor, and most homeowners do not need to take it into account.
There is also some disadvantage like the efficiency of polycrystalline-based solar panels is typically 13-16%. Which will increase the charging time of the battery but for simple electronics device polycrystalline is best.

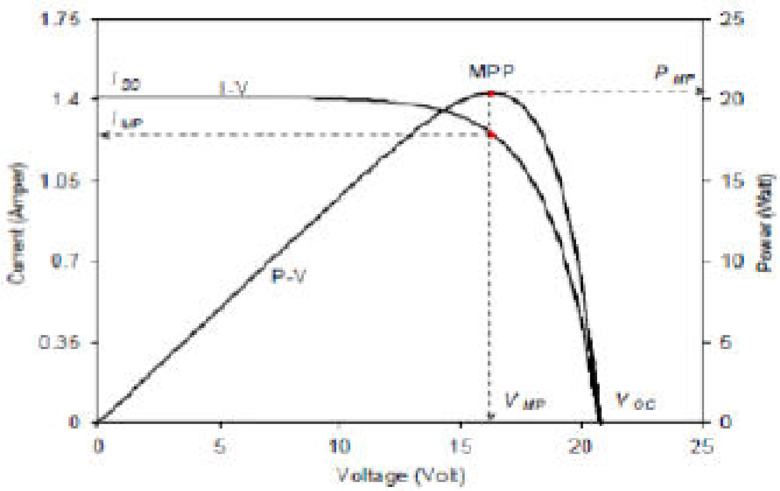


Figure 4.1: Typical I-V and P-V curves for a PV module

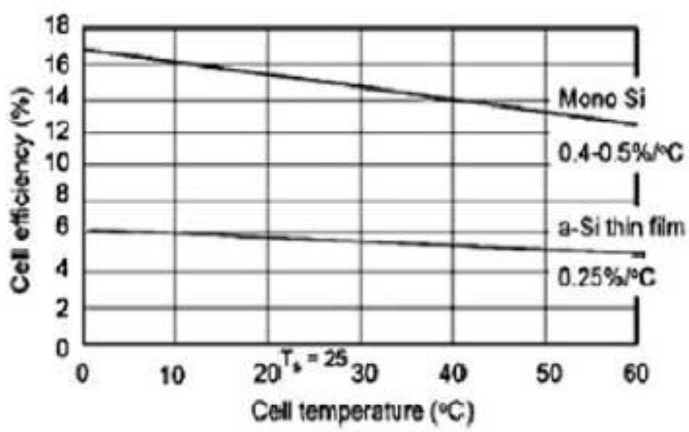


Figure 4.2: The relation between PV cell efficiency and temperature

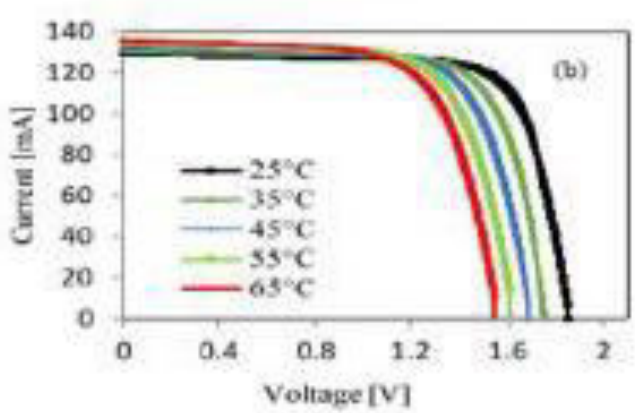


Figure 4.3: Current Vs voltage curves for p-Si

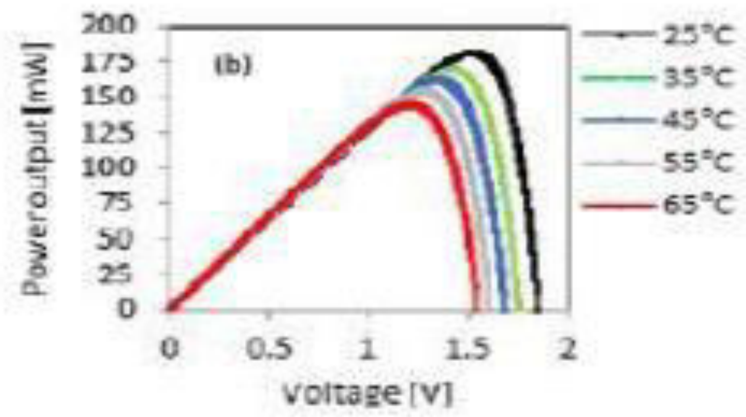


Figure 4.4: Output power Vs voltage curves for (a) p-Si

Output power demonstration of typical poly crystalline PV cells at different temperature

Temperature in Degree	p-Si mW
25	181.5
35	170.1
45	161.5
55	153.4
65	143

The drop in $Pmax$for typical the Polycrystalline solar cells in three regions

Temperature in Degree	p-Si
22-45	-11%
45-65	-11.5%
25-65	-21.2%

For Polycrystalline:
Typical module efficiency –-- 13-16 %
Best research cell efficiency---20.4%
Typical length of warranty---25years
Temperature resistance --- Less temperature resistant than mono
Additional details --- Less silicon waste in the production process

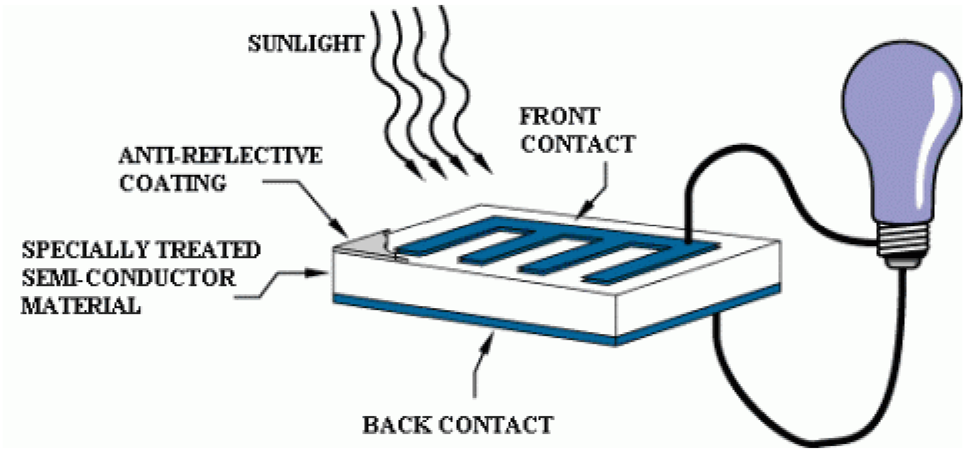


Figure 4.5: Model solar panel system

We have used 3W polycrystalline solar panel because this is the most efficient and available panel for small type power generation purpose**. [17]**

Solar Module Typical Performance Characteristics:

Peak Power:	**3w**
Maximum Power Voltage (Vmp)	**7V**
Maximum Power Current (Imp)	**428mA**
Open Circuit Voltage (Voc)	**8.4A**
Short Circuit (Isc)	**510mA**

STC (Standard Test Condition): AM 1.5 1000W/m 25c

It will cost 300 taka

Figure 4.6: 3Wp PV Module

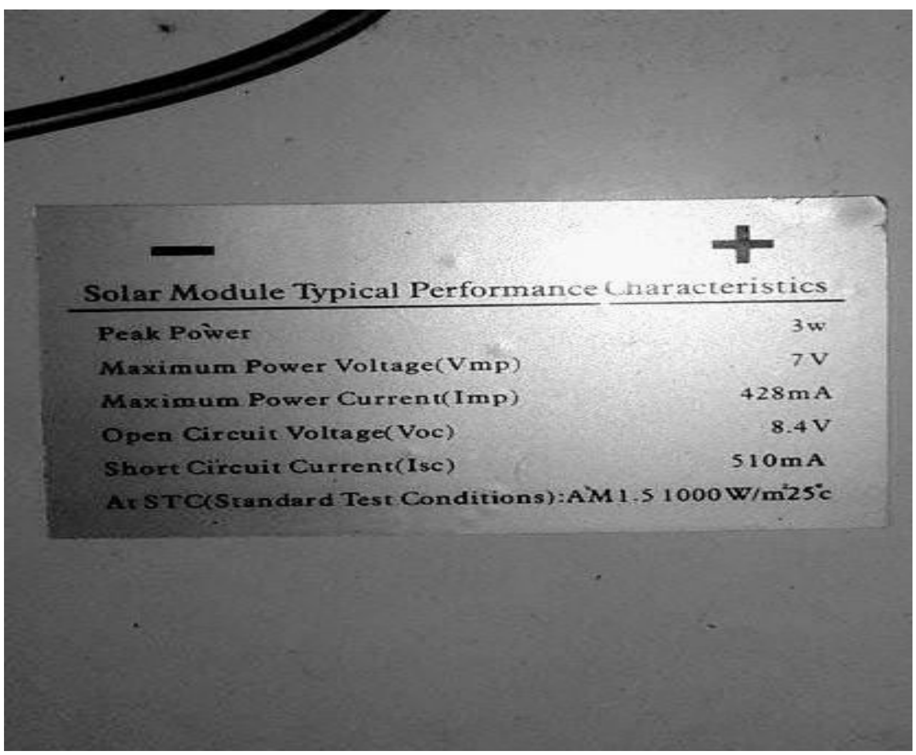


Figure 4.7: Specification of solar panel 3W

4.4 TP 4056 Module

We have used TP 4056 in light of the fact that it is an entire steady present/consistent voltage direct charger for single cell lithium-particle batteries. Its SOP package and low external component count make the TP4056 in a perfect world suited for convenient applications. The TP4056 can work inside USB and divider connector. Here no blocking diode is required due to the interior PMOSFET architecture and have avoid to negative Charge Current Circuit. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The charge voltage is fixed at 4.2V, and the charge current can be programmed externally with a single resistor. The TP4056 thus ends the charge cycle when the charge current drops to 1/tenth the customized an incentive after the last buoy voltage is come to. TP4056 different components incorporate current screen, under voltage lockout, programmed revive and two statuses stick to show charge end and the nearness of an info voltage. This tiny module is perfect for charging a single cell 3.7V 1 Ah. It is fine that when you charge a battery, the current (in mA) offered by the breakout board is 37-40% of the battery capacity (in mAh). For example, we used 3000mAh battery capacity to charge the battery we should adjust the resistance in a way that the current offered is approximately 370mA-400mA. This module will help us to protect the study lamp without any problem and damages.

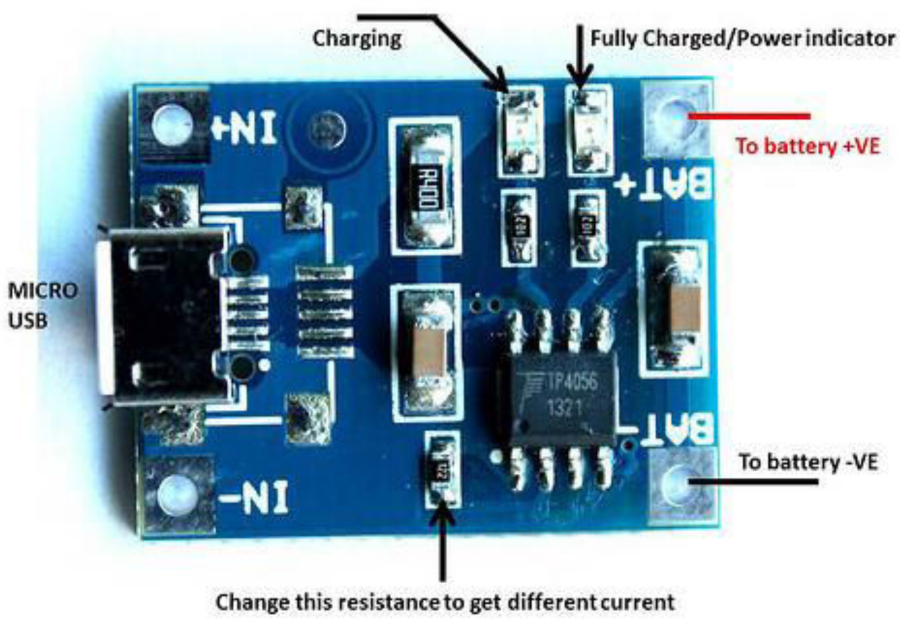


Figure 4.8: TP 4056 Module

Item Name: 5V Mini USB 1A Lithium Battery Charging Board

Charge module: Linear charging

Current: 1A adjustable

Charge precision: 1.5%

Input voltage: 4.5V-5.5V

Full charge voltage: 4.2V

Work temperature: -10℃ to +85℃

Inverse polarity: NO

LED indicator: Red is charging, and GREEN is full charged

Input interface: DC port

4.4.1 Using the Module

- 5V DC from solar panel to pads marked IN+ and IN- on left-hand side of the module
- Connect cell to charge to B+/B- pads on right-hand side of module
- A load (the battery to power) can be connected to the OUT+/OUT- pads on the right-hand side
- Important! Disconnect load when charging
- The red LED indicates changing in progress and green LED indicates charging has finished.
- Should not charge battery at a rate greater than 1C.

4.4.3 Application:

Things we can use to this module are Cellular Telephones, PDAs, GPS ·Charging Docks and Cradles ·Digital Still Cameras, Portable Devices ·USB Bus-Powered Chargers, Chargers

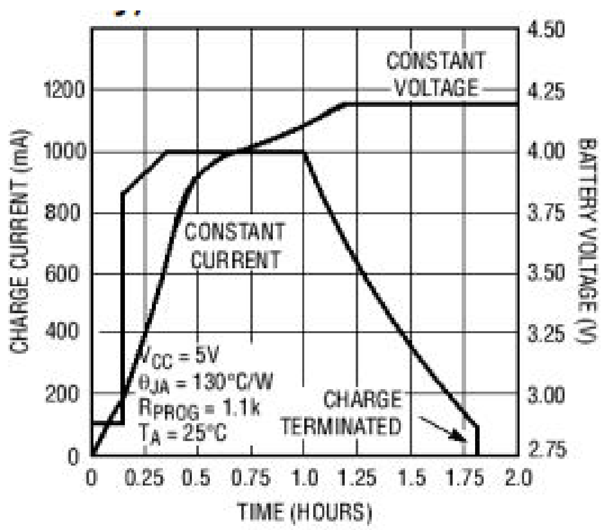


Figure 4.10: Complete Charge Cycle (1000mAh Battery) **[8]**

Charge state	Red LED $\overline{\mathrm{CHRG}}$	Greed LED $\overline{\mathrm{STDBY}}$
charging	bright	extinguish
Charge Termination	extinguish	bright
Vin too low; Temperature of battery too low or too high; no battery	extinguish	extinguish
BAT PIN Connect 10u Capacitance; No battery	Greed LED bright，Red LED Coruscate T=1-4 S	

Figure 4.11: Indicator light state **[18]**

Use the following table of resistance and current values to solder the right resistor to obtain the required current:

RPROG (k)	IBAT(mA)
30	50
20	70
10	130
5	250
4	300
3	400
2	580
1.66	690
1.5	780
1.33	900

Table 4.1: Various resisters in TP4056

4.5 Battery

We have used the lithium iron phosphate ($LiFePO_4$) battery which is also called LFP battery (with "LFP" standing for "lithium Ferro phosphate"), is a type of rechargeable battery which uses $LiFePO_4$ as a cathode material, and a graphitic carbon electrode with a metallic current collector grid as the anode. $LiFePO_4$ batteries have somewhat lower energy density than the more common lithium cobalt oxide ($LiCoO_2$) design found in consumer electronics, but offer longer lifetimes, better power density and are inherently safer. $LiFePO_4$ is finding a number of roles in vehicle and other electrical products use and backup power. Lithium-ion batteries are incredibly popular these days. You can find them in laptops, PDAs, cell phones and iPods. They're so common because, pound for pound, they're some of the most energetic rechargeable batteries available. **[19]**

4.5.1 Why Lithium is used in Batteries?

When electrons flow through a device such as a light bulb, the battery's energy issued to do work. This gives lithium-ion batteries a much better energy per volume ratio—or energy density—than an ordinary alkaline battery or other common rechargeable battery such as a nickel-metal hydride.

4.5.2 How Lithium-ion Batteries Work:

As with most batteries you have an outer case made of metal. The use of metal is particularly important here because the battery is pressurized. This metal case has some kind of pressure-sensitive vent hole. If the battery ever gets so hot that it risks exploding from over-pressure, this vent will release the extra pressure. The battery will probably be useless afterwards, so this is something to avoid. The vent is strictly there as a safety measure. So is the Positive Temperature Coefficient (PTC) switch, a device that is supposed to keep the battery from overheating.

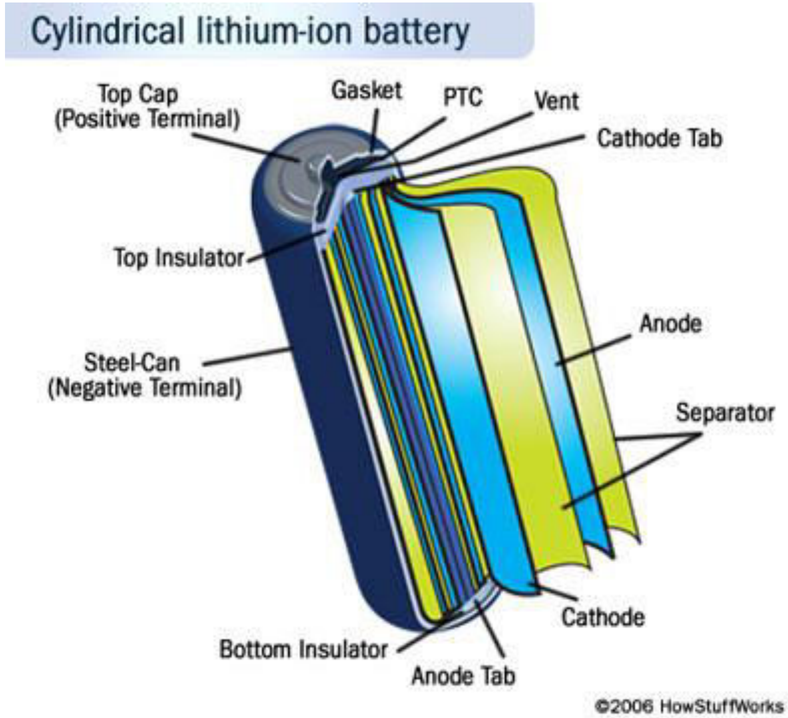


Figure 4.11: Lithium Ferro Phosphate Battery

This metal case holds a long spiral comprising three thin sheets pressed together:

- A Positive electrode
- A Negative electrode
- A separator

Inside the case these sheets are submerged in a natural dissolvable that goes about as the electrolyte. Ether is one normal dissolvable.

Each cell produces 3.7 volts. This is much higher than the 1.5 volts typical of a normal AA alkaline cell that you buy at any market and helps make lithium-ion batteries more compact in small devices. **[20]**

4.5.3 Delivering a Charge:

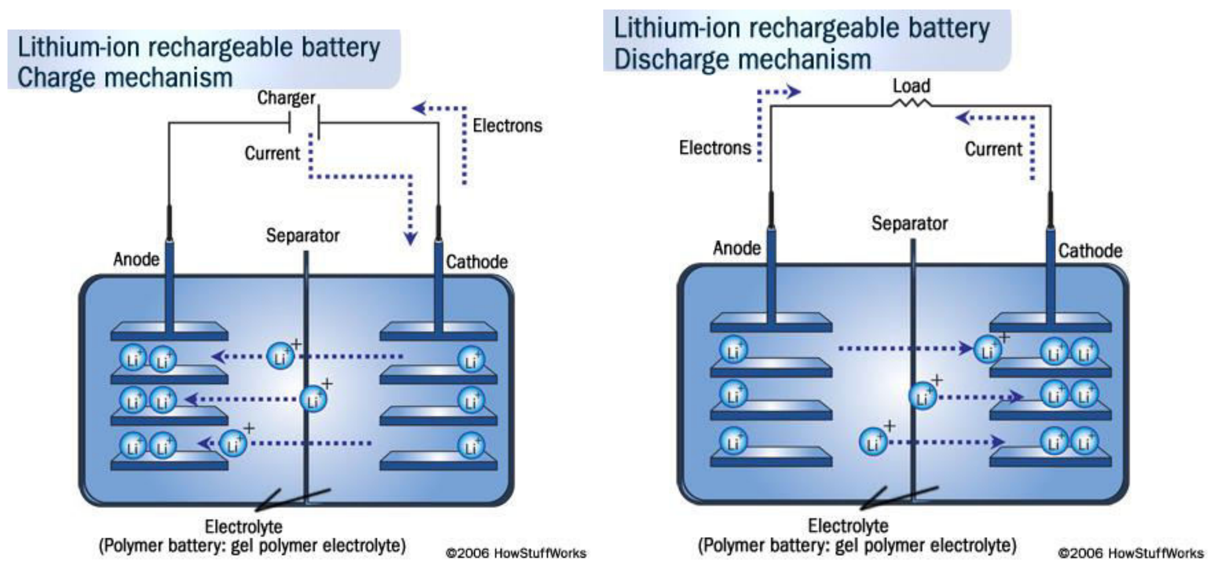


Figure 4.12: Lithium ion battery charging discharging time **[21]**

Today, lithium-molecule batteries are created with affirmations to oblige the charging voltage and to stop the battery if the temperature ends up being too high. Diverse assurances consider venting because of improvement of weight and maintain a strategic distance from too significant discharge, after which the battery can't be restored. This guarded equipment makes the battery safe, in any case it also decreases the division of the battery that is used to store essentialness, and besides slowly exhausts the battery despite when the device is off. Different research groups are in the midst of upgrading these and diverse parts of the lithium-molecule battery, and the future looks splendid for this enduring battery to appear in a consistently expanding number of devices, including the electric cars we hear such an extraordinary sum about these days.

4.5.4 Are Lithium Cobalt Batteries Safe?

Most lithium-ion batteries for portable applications are cobalt-based. The system consists of a cobalt oxide positive electrode (cathode) and a graphite carbon in the negative electrode (anode). One of the main advantages of the cobalt-based battery is its high energy density.

4.5.5 Advantage of Lithium Iron Phosphate (LiFePO4) Battery

Charge- discharge efficiency -- 96%, consistent throughout current range. Rated capacity is based on 20 minute discharge (3C), a one hour or longer discharge will actually give 10% more than the rated capacity.

Temperature resilience – Excellent – ambient temperatures up to 45 degree C will not affect the life of the cell at all.

Quick charging -- Standard time 1.30 hr. So it will be so helpful for charging with solar.

Charging Energy Source Size --- Only about 4% of the energy is lost to heat – big savings in charging energy and capital on PV installations Etc.

Pack capacity -- Pack can be sized to 60% of the “rated” capacity of a lead acid pack because of 96% efficiency and ability to discharge on regular occasion to 80% DOD with much lower effect on life reduction. **[22]**

4.5.6 How Long Do Lithium Ion Batteries Last?

- Lithium ion chemistry prefers partial discharge to deep discharge, so it's best to avoid taking the battery all the way down to zero. Since lithium-ion chemistry does not have a "memory", you do not harm the battery pack with a partial discharge. If the voltage of a lithium-ion cell drops below a certain level, it's ruined.

- Lithium-ion batteries age. They only last two to three years, even if they are sitting on a shelf unused. So if we keep using1 the battery with the thought that the battery pack will last five years. It won't. Also, if you are buying a new battery pack, you want to make sure it really is new.

- Avoid heat, which degrades the batteries.

So we used this lithium iron phosphate for a long survival and as a powerful source of light which will suitable for the studying purpose.

It will cost 150 taka.

4.6 High Power LED

The High Power LED is comparable in brightness with the standard incandescent and halogen light bulbs. This makes the High Power LED perfect for automotive, industrial, home and hobby applications.

Not only are they bright, they also consume a fraction of power of an incandescent bulb making them extremely energy efficient.

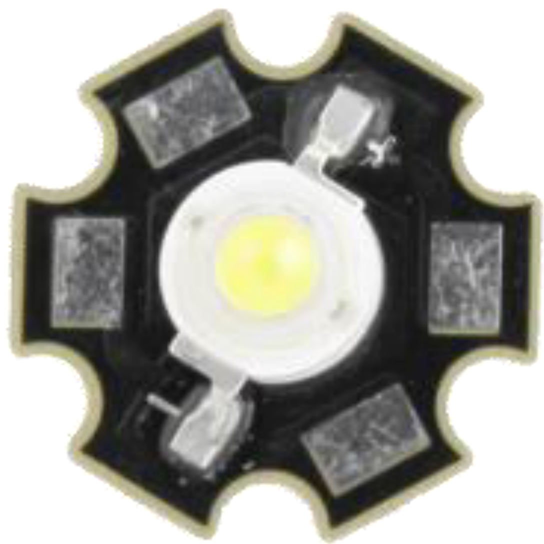


Figure 4.13: High Power LED

We have used High Power Led 1WATT 140-160LM. [5]

Specifications:
Material: Aluminum
Size: Customized

Product	Emitted Color	Color temp	IV_(lm)	View Angle	VF_(V)
SL1W-WC(120-140)	Pure White	6000-6500K	120-140lm	140*	3.0-3.6V

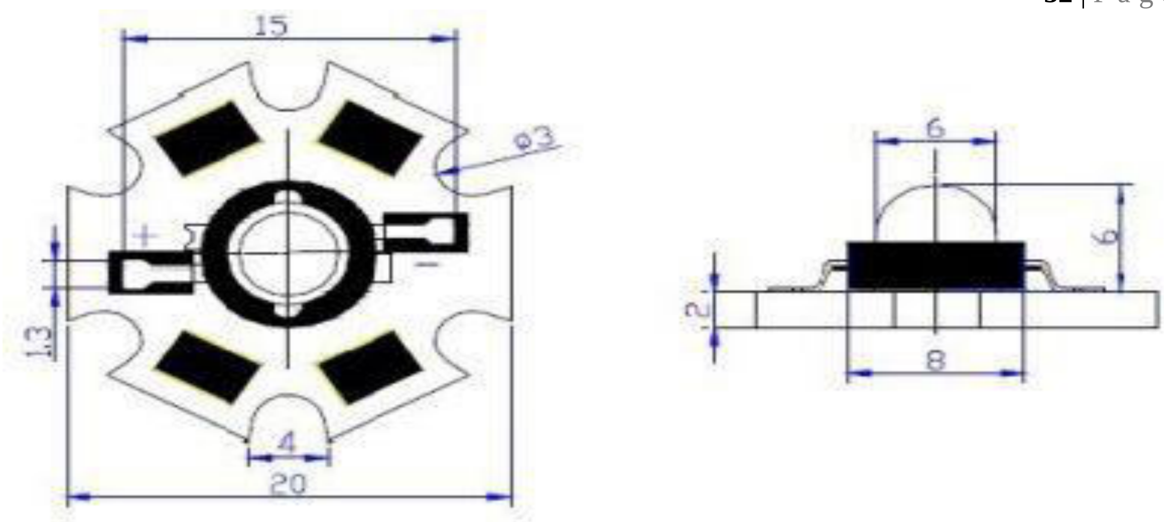


Figure 4.14: specified diagram of high power LED

4.6.1 Basic Advantages of LED Light

Energy efficient - LED's are now capable of giving output of 135 (lumen/watt)

Long Lifetime - 50,000 hours or more if properly engineered

Rugged - LED's are also called "Solid State Lighting (SSL) as they are made of solid material with no filament or tube or bulb to break

No warm-up period - LED's light instantly – in nanoseconds

Not affected by cold temperatures - LED's "like" low temperatures and will startup even in subzero weather

Directional - With LED's you can direct the light where you want it, thus no light is wasted

Excellent Color Rendering - LED's do not wash out colors like other light sources such as fluorescents, making them perfect for displays and retail applications

Environmentally friendly - LED's contain no mercury or other hazardous substances

Controllable - LED's can be controlled for brightness and color **[23]**

4.6.2 Why We Use LED for the Project?

- LEDs would perfect gas to utilization done requisitions that need aid liable on incessant on-off cycling, dissimilar to fluorescent Lights that wear out All the more rapidly At cycled frequently, or HID Lights that require quite a while in front of restarting.
- LEDs could precise effectively be darkened or strobe. LEDs light up extremely rapidly. An ordinary red pointer headed will attain full brilliance clinched alongside microseconds.

- LEDs mostly fail by dimming over time, rather than the abrupt burn-out of incandescent bulbs.
- LEDs could be really little Also need aid effortlessly populated onto printed circlet sheets.
- LEDs don't hold numerous mercury; Dissimilar to conservative fluorescent Lights**. [24]**

4.6.3 Disadvantages and Challenges in Using LEDs

LEDs are at present more costly, cost per lumen, on an underlying capital cost premise, than more other traditional lighting innovations. In any case, while considering the aggregate cost of proprietorship (counting vitality and upkeep costs), LEDs far outperform radiant or halogen sources and start to undermine smaller fluorescent lights. **[25]**

4.6.4 Cost Effective

The Chart Below thinks about various light sources in light of the life of the globule and the electrical cost at 10 pennies for each kWh (kilowatt hour).**[26]**

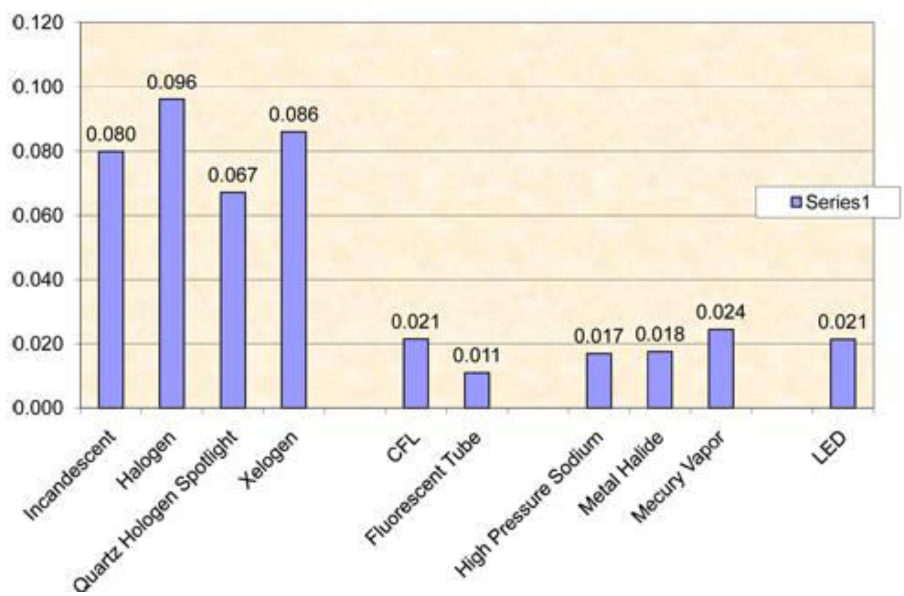


Figure 4.15: Various light sources in light of the life of the globule and the electrical cost **[27]**

4.7 Battery Level Indicator

This circuit is used to notify the user that how much charge is left and how long it can serve. We used 3 different resistors 17ohm, 15 ohm, 1k and three led indicator. Different resistors is for different led characters .

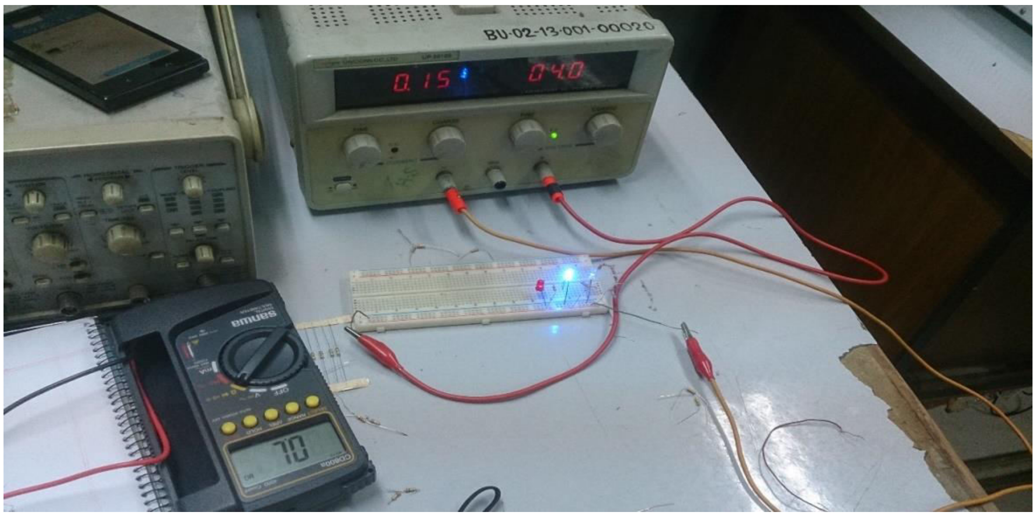


Figure 4.16: at 4 volt the blue light is on

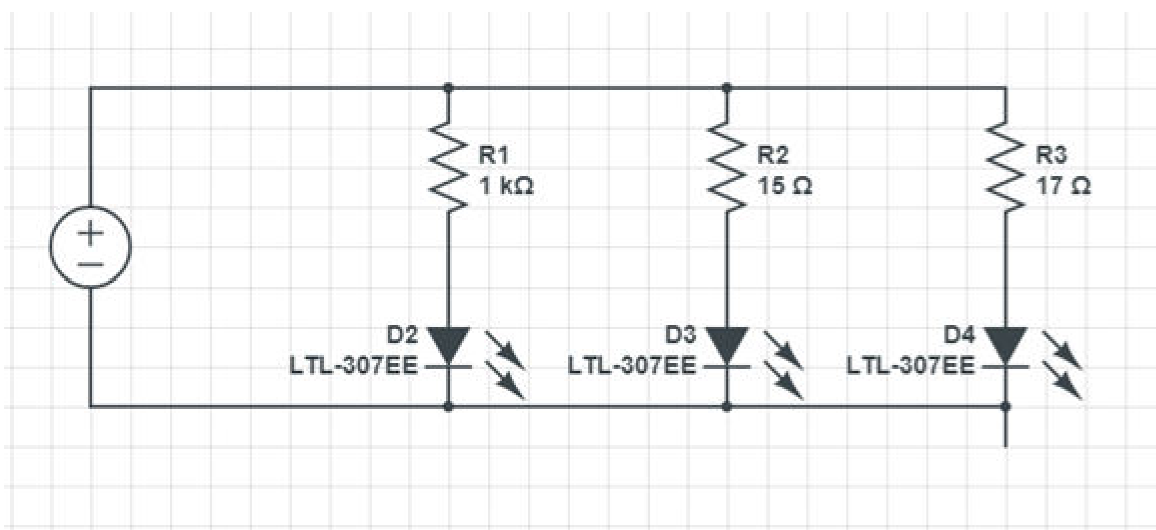


Figure 4.17: Battery indicator circuit

4.8 PCB Design

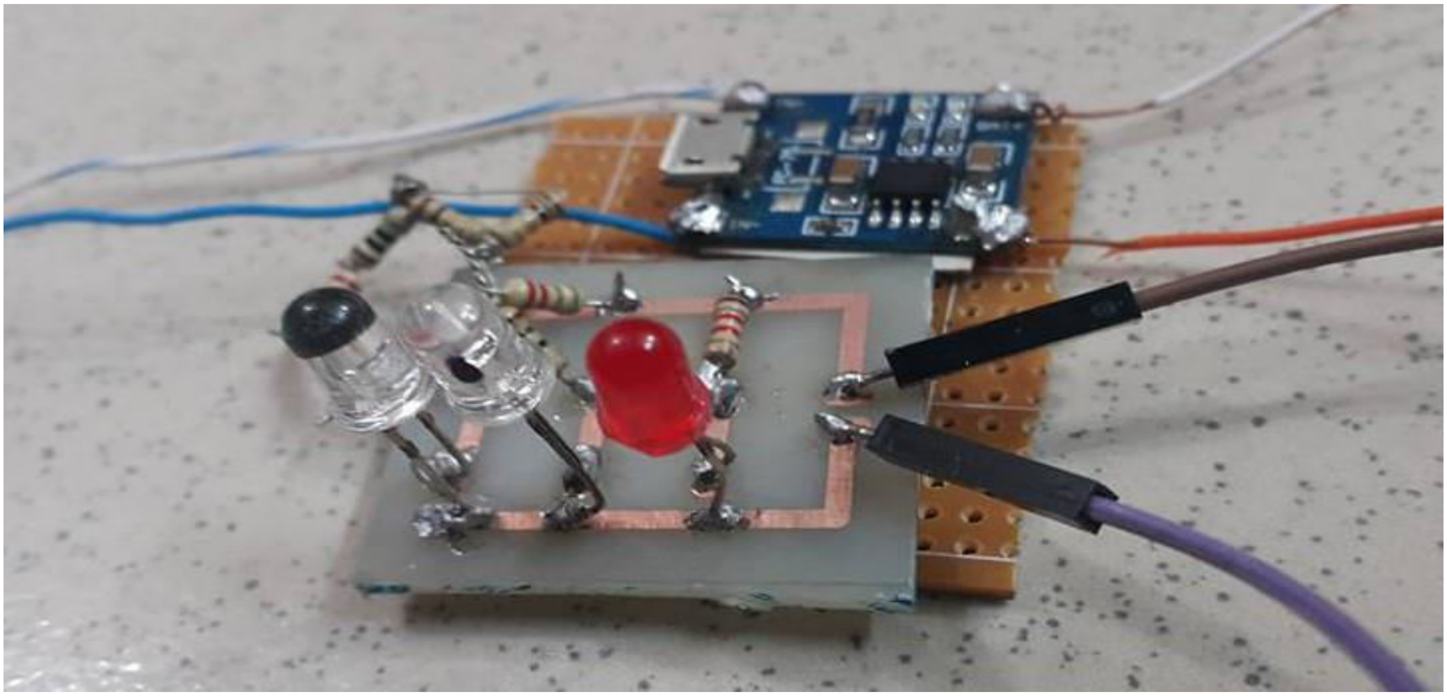


Figure 4.18: PCB of battery level indicator and TP 4506 Module

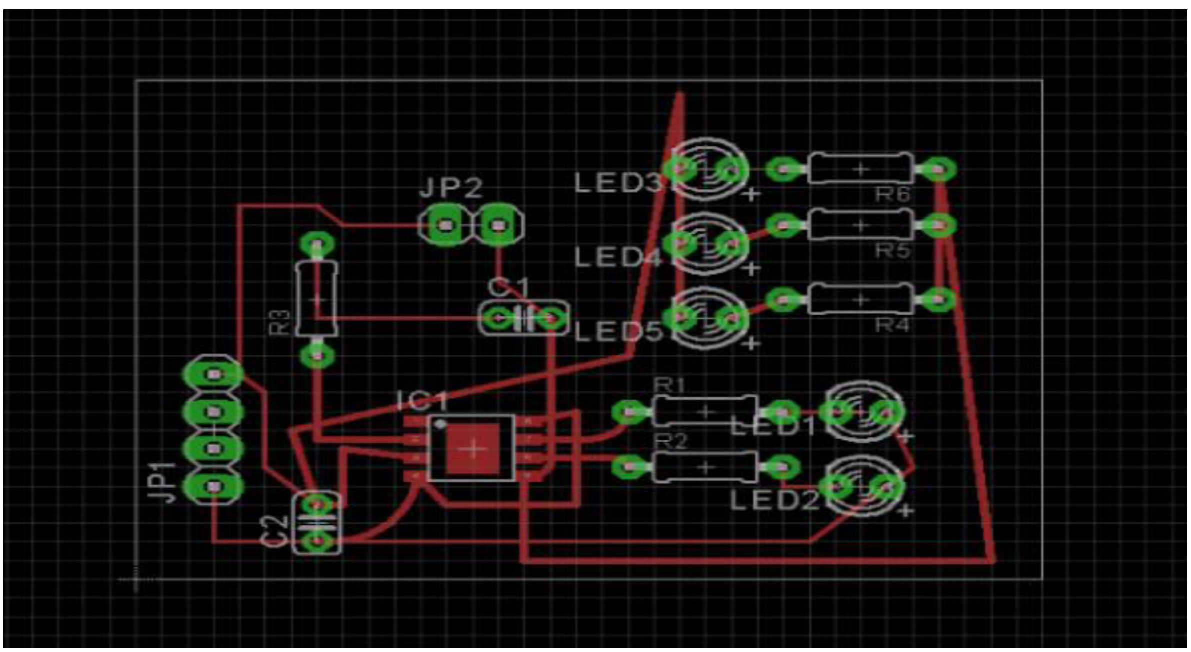


Figure 4.19: PCB design of battery level indicator and TP 4506 Module by EAGLE

Chapter 5

Testing Efficiency and Durability

5.1 Selection of LED

For studying purpose and for more light life we have to choose our led light for our solar study lamp. A chart with basic wattage recommendations based on age, type/amount of use, and type of light bulb is given below

	Footcandles	Incandescent	Halogen	Fluorescent	LED
5 - 12 yrs Child's Desk	25 – 50 FC	≤ 40 watts	≤ 20 watts	≤ 9 watts	1-3 watts
13 - 24 yrs Adolescent's Desk	20 – 75 FC	≥ 60 watts	≥ 50 watts	≤ 9 watts	≤ 5 watts
25 – 55 yrs Home Office	35 – 75 FC	≥ 60 watts	≥ 50 watts or 37 watts IR lamp	≤ 9 watts	5-10 watts
50 – 75 yrs Home Office	50 – 100 FC	≥ 100 watts	≥ 50 watts IR lamp	≤ 13 watts	5-10 watts
Reading in Bed	100 FC	–	–	–	3 watts

Table 5.1: LED selection

From the above chart we can choose 1 watt LED for our solar study lamp as it will consume less power and will the desired luminosity for a student.**[27]**

5.2 Selection of PV Panel

Firstly you need to know how much energy your battery can store and then select a Solar panel that can replenish your ‘stock’ of energy in the battery in line with your pattern of use.

There are three main things we considered to choose our Solar panel

- How much energy can our battery store?
- How much energy will our appliance use over a period of time?
- How much energy can a Solar panel generate over a period of time?

5.3 Maximum Energy Our Battery Can Store

We know that battery capacity (energy stored in a battery) is measured in watt-hours (Wh)/ kilowatt-hours (kWh)/amp-hours (Ahr).The Equation for getting the energy stores in a battery is given below

Battery size in AH * Battery Voltage = Power available in watt hours

For Our battery the calculation is:

3000mAH * 4V = 12 WH

This justifies that the battery can supply 1w for 12 hours. We have to keep in mind that the more energy we take, the faster the battery discharges. Our minimum required voltage is 2.7V so we can’t take all the power from the battery when the battery voltage drops below 2.7V . **[28]**

5.4 Energy that Our Appliance Use Over a Period of Time

We know that the power consumption of any electronic device (example: LED light) is given in Watts. To calculate the energy we need to multiply the power consumption by the hours of usage. We are using a LED light which consumes 1W power and we are using it for 8 hours (approximate) .So usage of the LED is

1w * 8 hours per day = 8w per day **[28]**

5.5 Solar Panel Size

Our power requirement is 8w per day. From the average of our Data sheet we got that we gets at least 3 hours (minimum) sunlight everyday .we could use this equation below for finding the peak power of our solar panel. **[28]**

Watts required / time of year sunshine hours = panel size

→ 8 / 3 = 2.67W panel

As we can't get a 2.67W solar panel we used a 3Wsolar panel for this application.

5.6 Selecting the right technology:

Solar panel can be classified into 2 categories based on cell structure .they are

- Crystalline silicon
- Amorphous silicon or thin-film

Again The crystalline silicon solar panel can be classified into 2 categories

- Mono-crystalline
- Poly crystalline

The comparison between different types of solar cell technologies are given below

Mono-crystalline	**Poly crystalline**
• Mono-crystalline solar panels have the highest efficiency rates as they are made of highest grade silicon	• polycrystalline silicon is simpler and can be used for household activity
• Performs great in low light	• Performance is not good in low light
• Expensive	• Less expensive

Table 5.2: Selecting the right technology

For making our product cheaper and user friendly we used 3W poly crystalline solar panel. **[29]**

5.7 Testing of the Solar Panel

We need to check that our solar panel is working properly, besides we want to know that what output our panel is giving. For this reason we used a multi-meter to measure current and voltage. We got the voltage (V) and current (A) ratings from the back of our panel

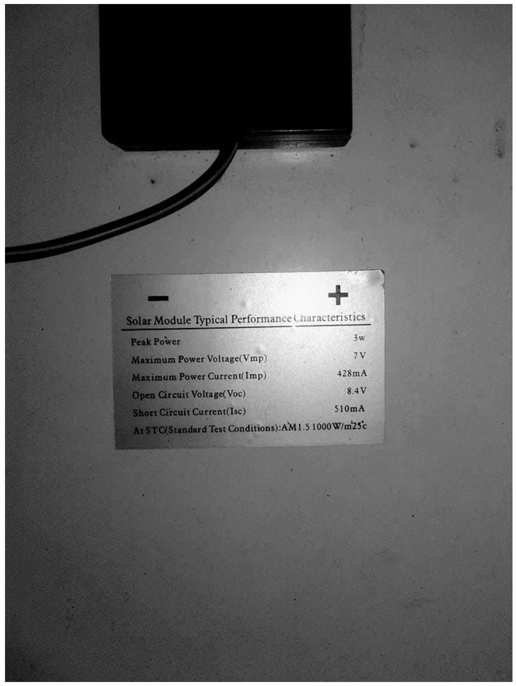


Figure 5.1: Specification of Solar panel

Firstly we checked that sunlight condition is suitable for measuring the rated output from our panel checked for short circuit and the polarities when connecting solar panels

5.8 Voc Test

The solar panel was faced to sunlight and set the multi-meter to measure Voltage. We measured the voltage between the +ve and -ve terminals of the panel .sometimes we got the value negative because we have connected the negative contact of the voltmeter to the positive contact of the panel and the positive contact of the voltmeter to the negative contact of the panel.

Figure 5.2: Voc Test

5.9 Isc Test

For measuring short circuit current we set the multi-meter at10A (for safety) at least to start with. You can change the setting later if required. Here we also got negative results sometimes as we have connected the negative contact of the voltmeter to the positive contact of the panel and the positive contact of the voltmeter to the negative contact of the panel.

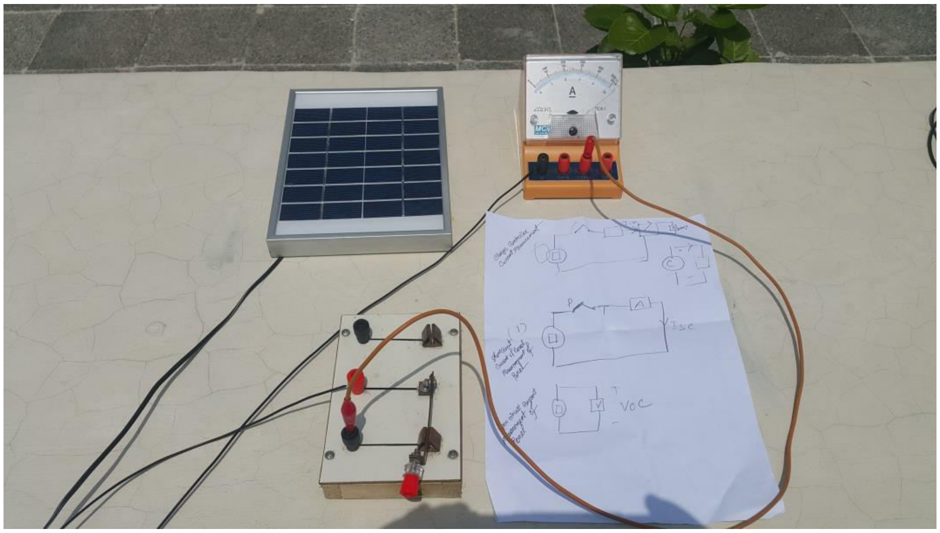


Figure 5.3: Isc Test

5.10 Battery Charging Operation

For battery charging we used the circuit below, besides solar power we can work with USB and wall Adapter by this charge controller circuit. For this circuit no blocking diode is required because we used a PMOSFET internally to demolish negative charge current. The output voltage is fixed at 4.1V

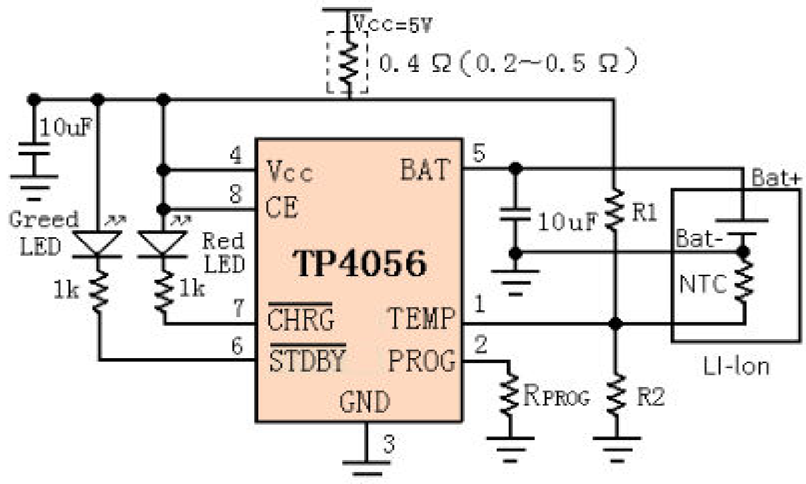


Fig5.2:TP4056 module

After connecting the circuit with our solar panel blue light shows up that means the circuit is ready to charge the battery. By using multi meter we measured the open circuit voltage of the circuit and we got the exact same value 4.1V. When we connected the battery the red light shows up that means the circuit is in charging period. If the battery is fully charged the blue light again turns on. When disconnecting the solar panel, charge controller and battery we disconnected the panel from the charge controller first then disconnected the charge controller from the battery. For avoiding damage we connect the charge controller to the battery first and then connected t the solar panel.

However, we have taken 52 data from our selected area and the datasheet is given below

DAY	TEMPERATURE	VOLTAGE (PANEL)		Isc(mA)	TP4056 MODULE		CHARGING TIME		DISCHARGE TIME	USABLE LIGHT		BAT VOLT	
		Voc	Vin		Iout	Vout	SUNNY	CLOUDY				Vb(FULL)	LED CONNECTED
22-Jun	31*--27*	7-7.03	5-5.1	400	0.2	4-4.05	2pm-6pm		11pm-12am	3.24v-2.7v		3.24	3.15
23-Jun	34*--27*	6-7.5	4.5-5.23	300-410	0.1-0.2	4.03	12.30pm-1pm	1pm-7.10pm	10.41pm-10.30am	3.80v-2.62v		3.69	3.6
24-Jun	33*--28*	7.16-7.01	5.58	460	0.2	4.02	10.30am-	12.30pm-2pm	8pm-3.30am	3.94v-2.7v		3.94	3.85
25-Jun	32*--27*	7.08-7.01	5.6	400-410	0.2	4.05		9.00am-6.40pm	9pm-4pm	3.98v-2.7v		3.98	3.88
26-Jun	32*--27*	7.02-7.2	5-5.08	400-420	0.2	4.05-4.1	10am-6pm		10pm-2pm	3.97v-2.7v		3.97	3.88
27-Jun	33*--28*	7.01	5.1	400	0.2	4.03	2pm-5pm		6pm-8pm	3.4v-2.7v		3.4	3.31
28-Jun	32*--28*	7.02	5.01	400	0.2	4.02		12pm-7pm	6.30pm-8pm	3.2v-2.7v		3.2	3.11
29-Jun	33*--28*	7.12-7.05	6.33	410	0.2	4.02	11am-7pm		9pm-4pm	3.78-2.7		3.78	3.71
30-Jun	32*--27*	7.08-7.01	5.6	410	0.2	4.1		9.00am-6.40pm	9pm-4pm	3.98v-2.7v		3.98	3.88
01-Jul	32*--28*	7.02	5.01	400	0.2	3.9		12pm-7pm	6.30pm-8pm	3.2v-2.7v		3.2	3.11
02-Jul	30*--27*	7-7.03	5-5.1	400	0.2	3.95	2pm-6pm		11pm-12am	3.24v-2.7v		3.24	3.15
03-Jul	29*--27*	7.1-5.8	5.4	410	0.1-0.2	3.9	6am-5.40pm		6.43pm-9.46pm	3.65	3.42	3.65	3.57
04-Jul	29*--26*	7.2-7.5	6.33	450	0.2	3.6	10am-6pm		6.26pm-11.40pm	3.66	3.46	3.66	3.6
05-Jul	29*--26*	7.2-7.41	5.9	450	0.2	3.82	10.05am-5.17pm		5.40pm-11.36pm	3.73	3.47	3.73	3.63
06-Jul	32*--27*	7.08-7.01	5.6	410	0.2	4.1		9.00am-6.40pm	9pm-4pm	3.98v-2.7v		3.98	3.88
07-Jul	31*--27*	7-7.03	5-5.1	390	0.2	4.02	2pm-6pm		11pm-12am	3.24v-2.7v		3.24	3.15
08-Jul	32*--28*	7.02	5.01		0.2	4.01		12pm-7pm	6.30pm-8pm	3.2v-2.7v		3.2	3.11
09-Jul	33*--28*	7.34	5.04	420	0.2	4.1	12.30pm-6.30pm		7.20PM-1.20AM	3.87	3.29	3.87	3.8
10-Jul	29*--27*	7.1-5.8	4.94	350	0.2	3.9	6am-5.40pm		6.43pm-9.46pm	3.65	3.42	3.65	3.53
11-Jul	29*--26*	5.50-7.34	4.36	350	0.1-0.2	3.6	10am-6pm		6.26pm-11.40pm	3.66	3.46	3.66	3.57
12-Jul	31*--25*	7.34	5.17	420	0.2	4.04	10.40am-6.20pm		7pm-12am	3.61	3.33	3.61	3.57
13-Jul	32*--26*	6.85	4.741		0.2	4.01	10.53am-6.15pm		7pm-11.20pm	3.71	3.29	3.71	3.65
14-Jul	33*--27*	7.75	6.42	390	0.2	4.02	11am-6.20pm		6.10pm-12am	3.89	3.31	3.89	3.8
15-Jul	34*--27*	7.81	6.36	500	0.2	4.02	9.53am-5.32pm		6pm-11.52pm	3.91	3.3	3.91	3.83
16-Jul	35*--28*	7.84	6.54	500	0.2	4.01	11.13am-6.47pm		6.50pm-12.45am	3.91	3.41	3.91	3.81
17-Jul	35*--27*	6.49	5.54	390	0.2	4.01	7.51am-6pm		6.30pm-11pm	3.91	3.63	3.91	3.81
18-Jul	34*--27*	7.25	6.5	410	0.2	4.03	11am-6.20pm		6.35pm-11.47pm	3.87	3.41	3.87	3.75
19-Jul	29*--26*	5.8	4.94	300	0.1-0.2	3.82	10.05am-5.17pm		5.40pm-11.36pm	3.73	3.47	3.73	3.75
20-Jul	28*--25*	6.49	5.8	390	0.2	4.01	7.51am-6pm		6.30pm-11pm	3.91	3.63	3.91	3.81
21-Jul	29*--26*	5.8	4.3	300	0.1-0.2	3.82	10.30am-6.30pm		5.40pm-11.36pm	3.73	3.47	3.73	3.63
22-Jul	32*--27*	7.08-7.01	5.6	410	0.2	4.01	9.00am-6.40pm		9pm-4pm	3.98v-2.7v		3.98	3.88
23-Jul	32*--26*	6.85	4.7		0.1	4.01	9am-6.15pm		7pm-11.20pm	3.71	3.29	3.71	3.68
24-Jul	28*--26*	5.50-7.34	5.9	350	0.1-0.2	3.6	8am-6pm		6.26pm-11.40pm	3.66	3.46	3.66	3.55
25-Jul	28*--25	5.50-7.34	4.94	350	0.1-0.2	3.6	10am-6pm		6.26pm-11.40pm	3.66	3.46	3.66	3.55
26-Jul	29*--25*	5.8	4.94	300	0.1-0.2	3.82	7.51am-6pm		5.40pm-11.36pm	3.73	3.47	3.73	3.65
27-Jul	33*--27*	7.75	6.42	390	0.2	4.02	11am-6.20pm		6.10pm-12am	3.89	3.31	3.89	3.8
28-Jul	34*--27*	7.75	6.42	390	0.2	4.02	10am-6pm		6.10pm-12am	3.89	3.31	3.89	3.8
29-Jul	31*--26*	7.34	6.14	420	0.2	4.04	10.40am-6.20pm		7pm-12am	3.61	3.33	3.61	3.51
30-Jul	33*--27*	7.75	6.42	390	0.2	4.02	6am-5.40pm		6.10pm-12am	3.89	3.31	3.89	3.8
31-Jul	34*--20*	7.81	6.57	500	0.2	4.02	10am-6pm		6pm-11.52pm	3.91	3.3	3.91	3.82
01-Aug	33*--27	7.34	6.31	420	0.2	4.1	12.30pm-6.30pm		7.20PM-1.20AM	3.87	3.29	3.87	3.79
02-Aug	31*--26*	7-7.03	5-5.1	400	0.2	4-4.05	2pm-6pm		11pm-12am	3.24v-2.7v		3.24	3.15
03-Aug	33*--27*	7.34	6.2	420	0.2	4.1	12.30pm-6.30pm		7.20PM-1.20AM	3.87	3.29	3.87	3.79
04-Aug	32*--27	7.08-7.01	5.6	410	0.2	4.02	9.00am-6.40pm		9pm-4pm	3.98v-2.7v		3.98	3.88
05-Aug	33*--28*	7.34	6.3	420	0.2	4.1	12.30pm-6.30pm		7.20PM-1.20AM	3.87	3.29	3.87	3.8
06-Aug	32*--27*	7.08-7.01	5.6	410	0.2	4.2	9.00am-6.40pm		9pm-4pm	3.98v-2.7v		3.98	3.88
07-Aug	33*--26*	7.34	6.3	420	0.2	4.1	12.30pm-6.30pm		7.20PM-1.20AM	3.87	3.29	3.87	3.8
08-Aug	33*--28*	7.81	6.5	500	0.2	4.02	11am-6.30pm		6pm-11.52pm	3.91	3.3	3.91	3.85
09-Aug	34*--28*	7.25	6.1	410	0.2	4.03	7am-4.30pm		6.35pm-11.47pm	3.87	3.41	3.87	3.87
10-Aug	33*--28*	7.16-7.01	5.58	460	0.2	4.02	10.30am-	12.30pm-2pm	8pm-3.30am	3.94v-2.7v		3.94	3.85

Table 5.3 : Solar study lamp Datasheet

However, we have tried to keep the battery operating voltage of its 80% as it maintains the healthy battery condition. The backup time we have fixed from the survey, now we have also met that requirement properly.

5.11 Battery Discharging Operation

Battery starts discharging when Led light is turned on. The fully discharge voltage is 1.7v at that point the led gives no light. From our data sheet we got that 2.7v is the minimum point as the light intensity goes down.

DISCHARGE TIME	USABLE LIGHT	BAT VOLT	
		CONTCT	LED CONNECTED
11pm-12am	3.24v-2.7v	3.24	3.15
10.41pm-10.30am	3.80v-2.62v	3.69	3.6
8pm-3.30am	3.94v-2.7v	3.94	3.85
9pm-4pm	3.98v-2.7v	3.98	3.88
10pm-2pm	3.97v-2.7v	3.97	3.88
6pm-8pm	3.4v-2.7v	3.4	3.31
6.30pm-8pm	3.2v-2.7v	3.2	3.11
9pm-4pm	3.78-2.7	3.78	3.71

Table 5.2: Battery discharging time

From the voltage level indicator we can see the discharge of the battery .when the battery is fully charged all led will glow. When 15% of the battery is discharged due to usage of the power for the study lamp the first led shuts down and the second led goes down when 25% battery is discharged. For safety purpose we should not use the lamp when only the red led is on. Because the more battery is discharged the more time it will take to charge fully and will decrease the life time of the battery.

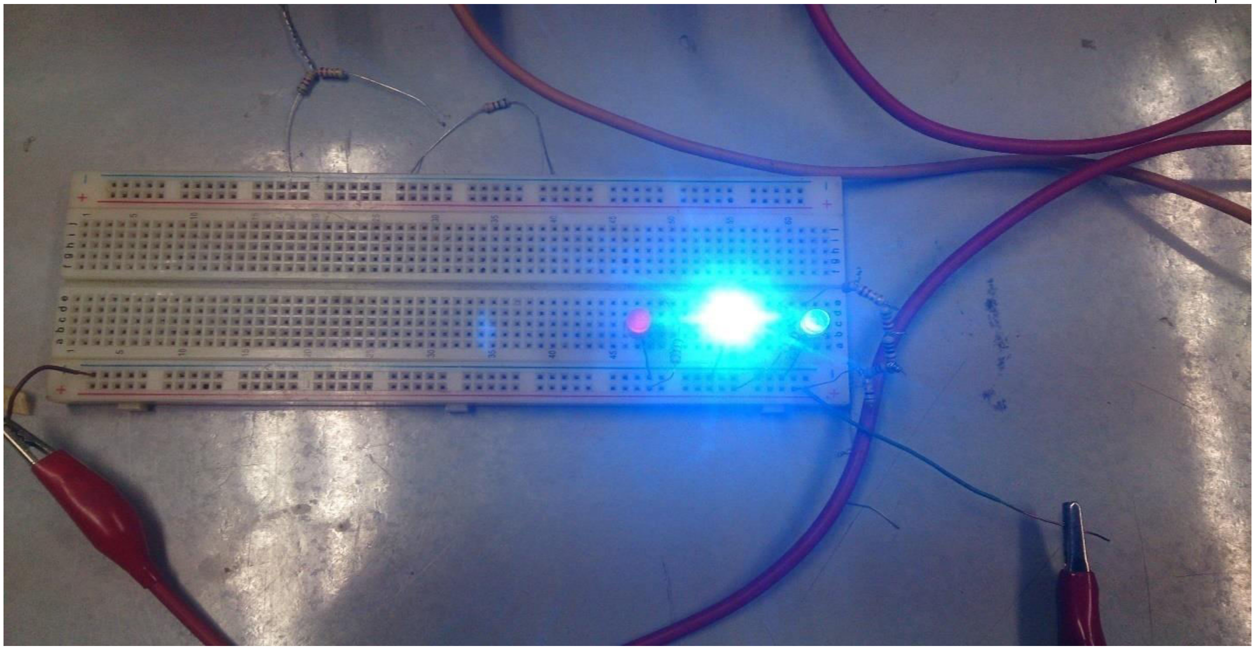


Figure 5.3: Active voltage indicator

5.12 Safety Check:

For any circuit we need to check that if the circuit is safety or not. For this reason we can take some steps of checking

- Checked for any kind of short circuit took place in the power path
- verified the circuit wiring is correct
- Checked all the connections for good electrical contact

5.13 Cost Analysis

The overall goal was building a low cost portable solar study lamp, with a better efficiency and long durability. After overall cost analysis of individual components in local Bangladeshi market we found out the total product cost which is 680.

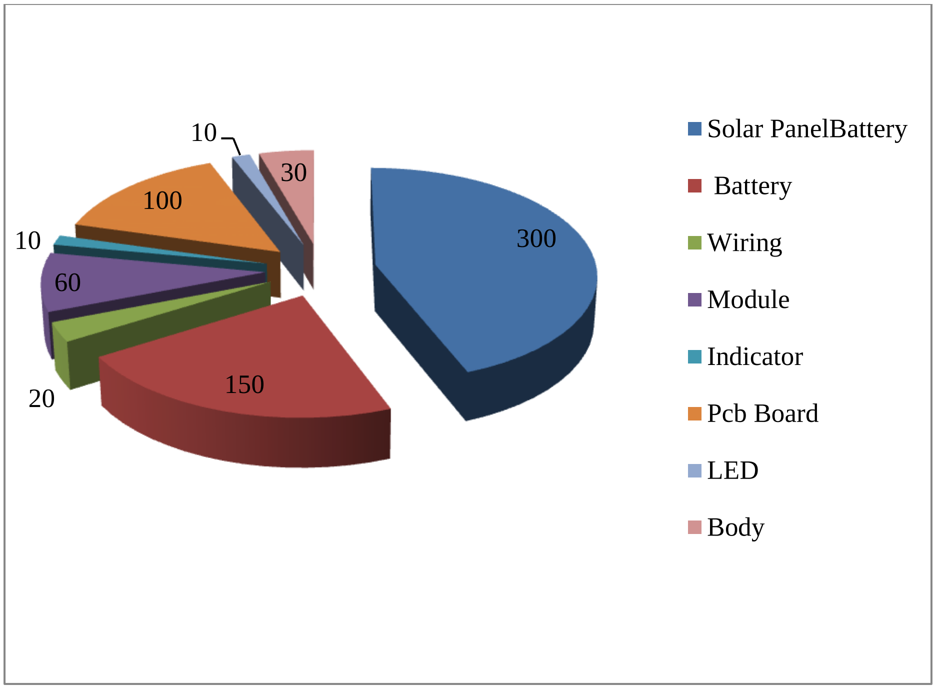


Fig5.4: Cost structure of final design

Total cost of the final product is 680 Taka

5.14 Economical Analysis

However, though the interviewed family's monthly cost for lighting is 233 tk, yearly their cost will be 233*12=2,796 tk, where one unit solar study lamp costing 680 tk only. The product we assume will last at least one year. So, it is clear that people can save 2,116 per year including more safety and environment friendly independent source of lighting.

5.14 The Solar Study Lamp

Figure5.6: Solar study lamp

Chapter 6

Solar Calculator

6.1 Theoretical Calculation Considering Real Time Condition:

Unfortunately, we cannot get 100% from any devices such as module; inverter because it depends on its efficiency and efficiency can be more reduced if we are considering other factors such as dust derate factor, mismatch factor, temperature derate, rate factor and many more. So, we have considered those factors to calculate those parameters in respect of Bangladesh for non-technical person who can easily do it by themselves.

However, we have considered autonomy (back up days) 3, battery efficiency 85%, temperature derate 97%, DOD 80%, rate factor 30% respectively for our calculation. Even for module affecting factors, we have set dust derate factor 10 %(90%) and mismatch factor 90% respectively.

1. Estimation of solar radiation? Peak sunshine hours, P.H= 5.4 hours.(5400/1000 hr per day)

2. Load calculation:

AC load:

S.No	Equipment	Quantity	Hours of Use	Load(W)	Load Consumption
1	Light	2	5	40	400
2	Fan	1	8	50	400
3	TV	1	4	50	200
	Total			140W	1000Wh

DC load:

DC load in Ampere hours = (5w * 2 hours) / 12 Volts = 0.833 Ah

3. Choose an Inverter: 158 Watts, 12 V, and Efficiency 90 %.

Total AC load in Ampere hour = (1000 Wh)/ (12 * 0.9)=92.5Ah.

Total daily load = AC+DC=93.43 + 0.833= 93.43Ah.

4. Battery Sizing:

Battery capacity = (autonomy*daily load) / (battery efficiency * Temp.derate * Rate factor* DOD)

No of Series batteries = Load nominal voltage / Battery nominal voltage

B.C = (3 * 93.43Ah) / (0.85*0.97*0.80*1.3) = 326.86 Ah

Choose a battery: 12V and 180Ah.

No. of Batteries in series = (12V) / (6V)=2

No. of batteries in parallel = (326.86Ah) / (180Ah)=2

5. Module Sizing:

Actual module output= module output * dust derate factor* mismatch factor

Module selected = 40 W, Imp = 2.41A

Module output = 2.41A * 5.4hours =13.04 Ah/day

Actual module output = 13.04Ah * 0.9* 0.9 = 10.56 Ah

Number of module of series = (12V) / (12V) = 1

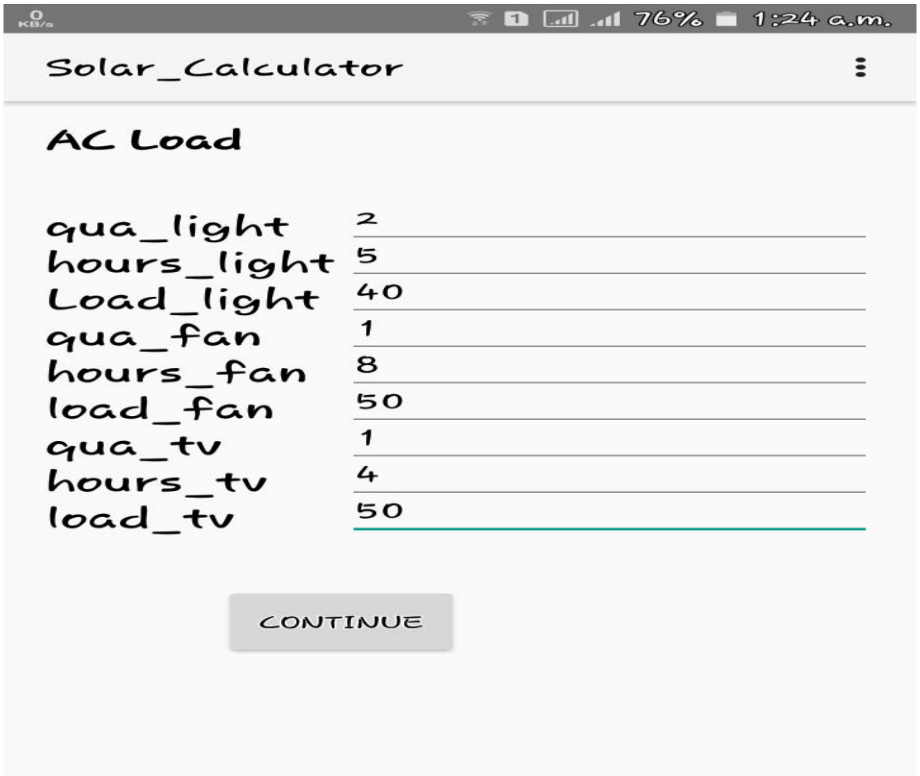
Number of module in parallel = (93.43Ah) / (10.56Ah) = 8.8

6.2 Pseudo Code for Solar Calculator:

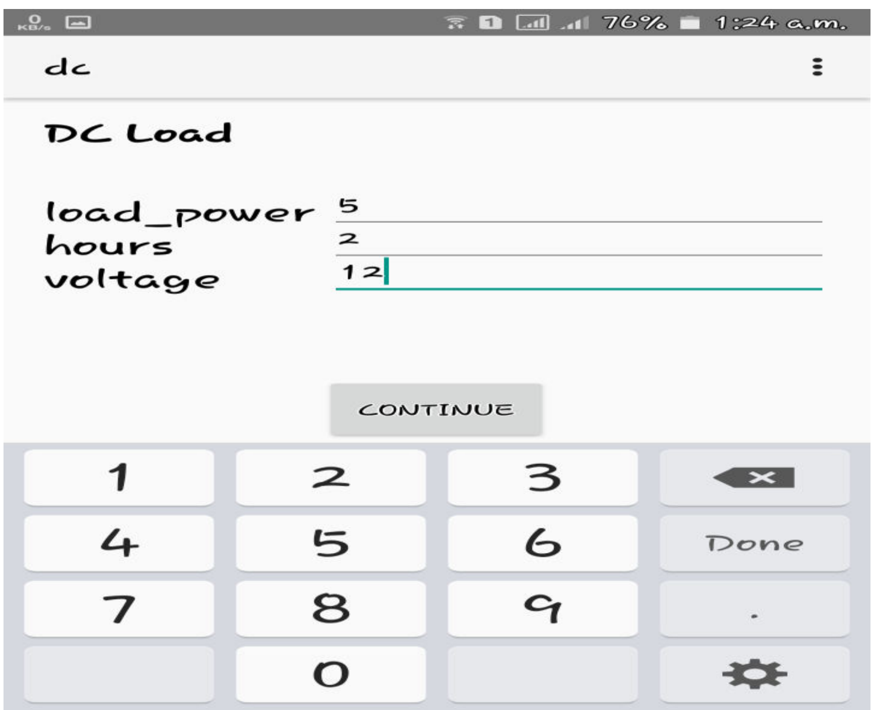
```
User input => q, h, l, INv, INe, Pdc, Hdc, OVdc, SBv, SBc, Pmo, Imo, Vmo

double => q, h, l, INv, INe, Pdc, Hdc, OVdc, SBv, SBc, Pmo, Imo, Vmo



total_load= summation of all load(l).

total_load_consumption= summation of all (q*h*l)

dc_load= (Pdc*Hdc)/OPdc


if (INv != 0){

INp=total_load*(1+.1);

AC_Load_in_ampere_hour_calculation = (total_load_consumption)/ (INv*(INe/100));

Total_Daily_load=AC_Load_in_ampere_hour_calculation+dc_load;

battery_capacity=(3*Total_Daily_load)/(0.85*0.97*0.8*1.3);

b_in_series=INv/SBv;

b_in_parallel=battery_capacity/SBc;

module_output=Imo*5.4;

actual_module_output=module_output*.9*.9;

m_s=INv/Vmo;

m_p=Total_Daily_load/actual_module_output;

        }
```

However, we have run the android application on a smartphone and its output was same as we mentioned in our theoretical part.

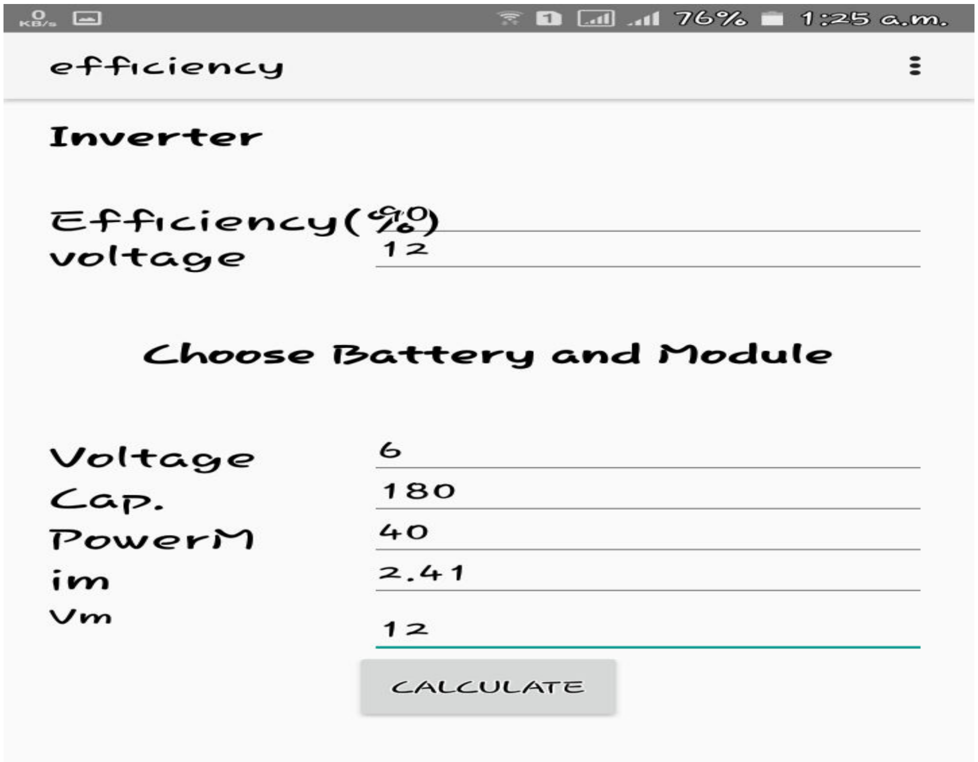
1st input appearance



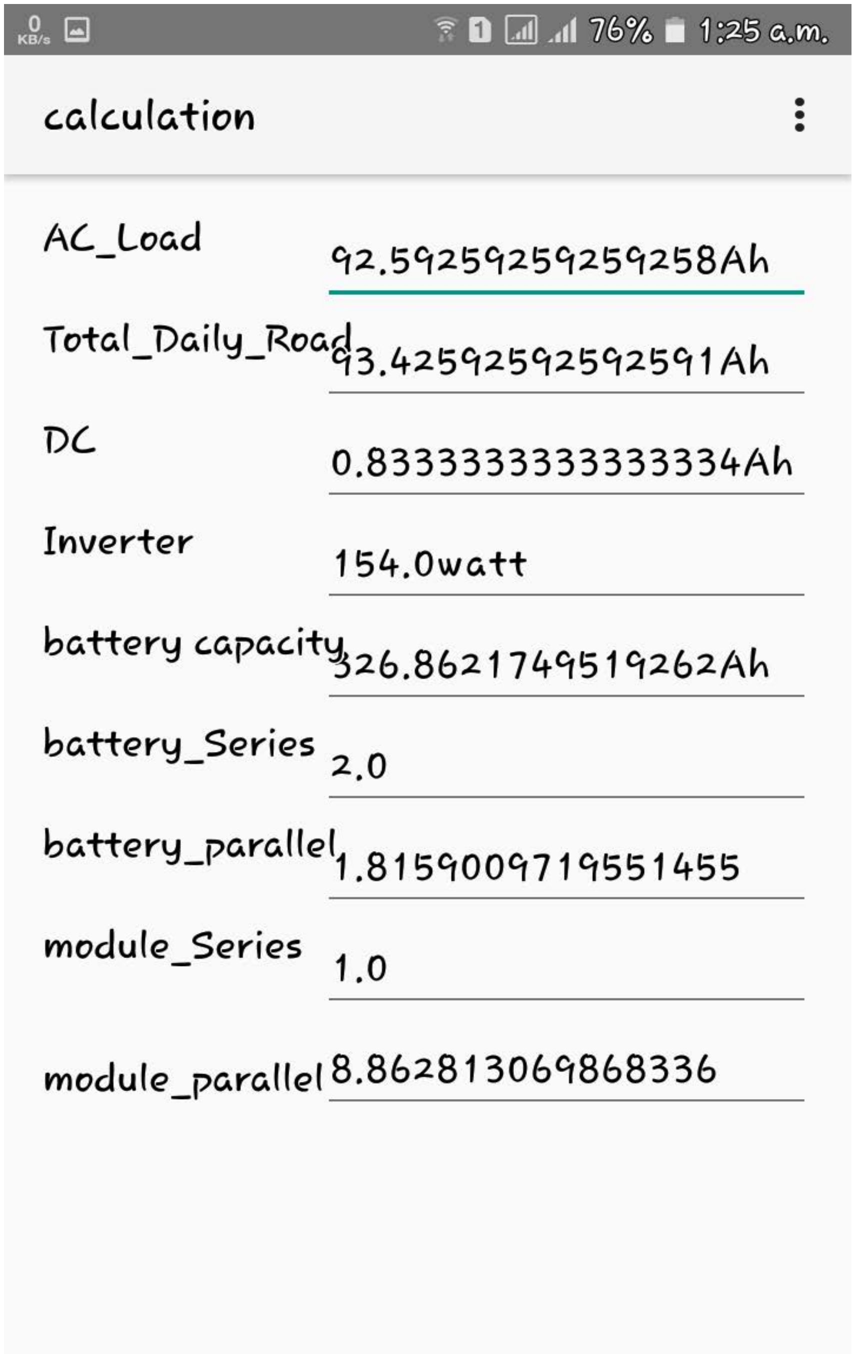
2nd Input appearance



3rd input appearance



4th Output appearance



6.3 Improvements Proposal:

a. No. of batteries or, module can be fraction number because of exact calculation, it can be rounded I assume.

b. efficiency effecting factors can be fixed by the user then it can be used in different areas.

c. Design interface can be more smooth and clear to user and stability improvement needed.

d. more feature can be added according to preferences.

Chapter 7

Conclusion

Conclusion:

This thesis paper is based on a practical calculation to identify a small problem and building a cost efficient solar study lamp for the lower income family children of Bangladesh who are deprived of minimum lightening for their education. Bangladesh is lacking continuous supply of power from national grid connection especially in rural and remote areas and during summer season it increases the more.

Future Work:

There are plenty of scopes for improvements in near future which can make it more efficient with more light weight, adding more features like mobile charging , as a power bank and with more beautiful design. Moreover, better design with more efficiency can be the best option in near future. Besides energy crisis is increasing day by day in Bangladesh and in rural areas the situation is already pretty bad. So, it’s a very small initiative to facilitate continuous education for at least 6 hours to help our rural area students. In larger scale with governments support or other donated fund, it can solve the problem forever cause solar energy is clean and renewable and ecofriendly.

REFFRERENCES

1. Adkins, E., S. Eapen, et al. (2010). "Off-grid energy services for the poor: Introducing LED lighting in the Millennium Villages Project in Malawi." Energy Policy 38(2): 1087-1097.
2. Alstone, P., A. Jacobson, et al. (2010). Illumination Sufficiency Survey Techniques: In-situ Measurements of Lighting System Performance and a User Preference Survey for Illuminance in an Off-Grid, African Setting. Lumina Project, LBLN. 7.
3. Friedman, L. (2010). Bringing Clean Light to Poor Nations and Moving Beyond Charity. New York Times.
4. Koch, J. C., Thomas (2006). Technologies and Business Models that Work in Developing Countries. International Conference on Information and Communication Technologies and Development School of Information Management and Systems at the University of California, Berkeley.
5. LADM (2008). Lighting Africa - Catalyzing Markets for Modern Lighting.
6. LADM (2010). Solar Lighting for the Base of the Pyramid: Overview of an Emerging Market
7. Velayudhan, S. K. (2003). "Dissemination of solar photovoltaics: a study on the government programme to promote solar lantern in India." Energy Policy 31(14): 1509-1518.
8. Wamukonya, N. (2005). "Solar home system electrification as a viable technology option for Africa's development." Energy Policy 35(6-14).
9. Adkins, E., S. Eapen, et al. (2010). "Off-grid energy services for the poor: Introducing LED lighting in the Millennium Villages Project in Malawi." Energy Policy 38(2): 1087-1097.
10. Advantages and limitations of the Different Types of Batteries - Battery University. (2011, November 14). Basic to Advanced Battery Information from Battery University. Retrieved April 28, 2012, from http://batteryuniversity.com/learn/article/whats_the_best_battery
11. http://www.reb.gov.bd/
12. http://www.bbs.gov.bd/site/page/b588b454-0f88-4679-bf20-90e06dc1d10b/Latest-Publications
13. http://data.banbeis.gov.bd/
14. http://www.eduicon.com/News/Details/4541.html
15. http://energyinformative.org/solar-cell-comparison-chart-mono-polycrystalline-thin-film/
16. https://dlnmh9ip6v2uc.cloudfront.net/datasheets/Prototyping/TP4056.pdf
17. http://energyinformative.org/solar-cell-comparison-chart-mono-polycrystalline-thin-film/
18. http://energyinformative.org/solar-cell-comparison-chart-mono-polycrystalline-thin-film/
19. http://electronics.howstuffworks.com/everyday-tech/lithium-ion-battery1.htm
20. http://physicscentral.com/explore/action/lithium.cfm
21. http://electronics.howstuffworks.com/everyday-tech/lithium-ion-battery1.htm.
22. http://www.freedomwon.co.za/home-battery/lithium-iron-phosphate
23. http://www.continental-lighting.com/led-basics/advantages-disadvantages.php
24. http://www.continental-lighting.com/led-basics/advantages-disadvantages.php
25. http://www.continental-lighting.com/led-basics/advantages-disadvantages.php
26. http://www.continental-lighting.com/led-basics/advantages-disadvantages.php
27. http://www.lightology.com/index.php?module=how_to&sub=desk_task_lighting
28. http://www.nit.ac.in/teqip/pdf/REPORT.pdf
29. http://www.energy.ca.gov/reports/2001-09-04_500-01-020.PDF
30. https://publish.pothi.com/preview/?sku=ebook3601

Appendix 1

Survey for Solar Study Lamp 2017

Name:

Total Family Members:

How many of them going to School:

Address:

LIGHTING SOURCE:

1. What do you use for lighting?
2. How many kerosene lamps or candles do you light at the same time?
3. Who purchases the candles/kerosene?
4. How many times per month does the man or woman buy candles/kerosene?
5. How many kilometers from your house is the shop where you buy candles/kerosene?
6. How much money do you spend per month on candles/kerosene?
7. What activities do you and your families do at night using the light?
8. Do your children light the candles/kerosene by themselves?
9. How many hours per night do you use lighting?
10. Have you seen a solar panel being used?
11. What kind of work do you do for income?
12. In which month does your household have the most income?
13. About how much income do you think your household could earn in a month?
14. What is one advantage of solar lighting over candles/kerosene?
15. If electricity available then how many times you have to face load shedding?
16. How much do you have to pay per unit electricity for a month?

Solar study lamp:

1. How much would you pay for the SOLAR STUDY LAMP?
2. Who would make the decision to buy a SOLAR STUDY LAMP?
3. Where do you think the SOLAR STUDY LAMP should be sold?
4. If it is locally available, how many chances do you have to buy it?
5. What kind of warranty would you want?
6. If the price was good, why would you buy a SOLAR STUDY LAMP?
7. Do you know where you can buy rechargeable batteries?

USER PREFERENCES:

1. How many hours do you need to light your home?
2. Where do you want to use the lamp besides study?
3. Once buy a solar study lamp how many months do you expect it will provide you the lighting service properly?
4. What alternative sources that you think better from SOLAR STUDY LAMP?

Appendix 2

Pseudo Code for Solar Calculator

User input => q, h, l, INv, INe, Pdc, Hdc, OVdc, SBv, SBc, Pmo, Imo, Vmo

```
double => q, h, l, INv, INe, Pdc, Hdc, OVdc, SBv, SBc, Pmo, Imo, Vmo
total_load= summation of all load(l).
total_load_consumption= summation of all (q*h*l)
dc_load= (Pdc*Hdc)/OPdc
if (INv != 0){
INp=total_load*(1+.1);
AC_Load_in_ampere_hour_calculation = (total_load_consumption)/ (INv*(INe/100));
Total_Daily_load=AC_Load_in_ampere_hour_calculation+dc_load;
battery_capacity=(3*Total_Daily_load)/(0.85*0.97*0.8*1.3);
b_in_series=INv/SBv;
b_in_parallel=battery_capacity/SBc;
module_output=Imo*5.4;
actual_module_output=module_output*.9*.9;
m_s=INv/Vmo;
m_p=Total_Daily_load/actual_module_output;
        }
```

However, we have run the android application on a smartphone and its output was same as we mentioned in our theoretical part.