FINANCIAL ANALYSIS OF SOLAR PV SYSTEM IN BANGLADESH

A Project and Thesis submitted in partial fulfillment of the requirements for the Award of Degree of

Bachelor of Science in Electrical and Electronic Engineering

BY

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Certification

This is to certify that this project and thesis entitled “Financial Analysis of Solar PV System in Bangladesh” is done by the following students under my direct supervisor and this work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. The presentation of the work was held on 31 October 2020

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Dedicated to

“My Parents”

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List of Abbreviations

PDB = Power Distribution Board.
PPP =Public-private partnership.
UCS = unified computing system.
NREL = National Renewable Energy Laboratory.
NGO = Non-governmental organization.
BRAC = Building Resources across Communities.
IDCOL = Infrastructure Development Company Limited
SHS =Hollow Structural Section, BDT = Bangladesh Taka
RET = Resolution Enhancement Technology
BCSIR = Bangladesh Council of Scientific and Industrial Research
LGED = Local Government Engineering Department
DFID = Department for International Development
BCAS = Bureau of Civil Aviation Security
MSL = Mean Sea Level, IEC = International Electro technical Commission
SREDA = Seaton Regional Economic Development Authority
STC = Society for Technical Communication
IPP = Integrated Performance Primitives
DESCO = Dhaka Electric Supply Company Limited
BAEC = Bangladesh Atomic Energy Commission
ADB = Asian Development Bank, LGED = Local Government and Engineering Department
ETSU = Energy Technology and Services Unit
SREDA = Sustainable and Renewable Energy Development Authority
IDCOL = Infrastructure Development Company Limited
GEF = Global Environmental Facility
WECS = Wind Energy Conversion Systems
BCSIR = Bangladesh Council of Scientific and Industrial Research
BPDB = Bangladesh Power Development Board
LGED = Local Government Engineering Department
BUET = Bangladesh University of Engineering and Technology
CWET = Center for Wind Energy Technology
HAWT = hub wind turbines
WT = wind turbines, VAWT = vertical pivot wind turbines
CSP = concentrated sun-oriented power
MPPT = might incorporate a greatest power point tracker
REB = Rural Electrification Board
HDI = Human Development Index

List of Symbols

λ	Wavelength
λ_B	Bragg wavelength
n_{eff}	Effective index
z	Position along the grating
n	Mode index
f	Fundamental Frequency
ω	Angular frequency
M	Modulation Index
T	Fundamental Time Period

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ABSTRACT

Increasing demand for power is now causing engineers and scientists to talk of renewable energy sources and the lack of existing energy supplies. It has been used more and more in recent years to produce electricity. The design of the solar home device often allows the usage of renewable energy appealing. Solar home systems do not need fuel and maintenance is very low. Free electricity, stable control, versatility and fast deployment are another benefit of PV program.

Author discussed ""Financial Analysis of Solar PV System in Bangladesh"". Finally, author try to analyzed solar home system per unit cost, We can see here the calculation with Retscreen software, in this calculation we are working with 100 kw and after getting the total cost with the rest of the transportation cost is done together, After doing that 100kw calculation, we connected 20 houses, before that we took out the cost of 20 houses per month. After that I can sell the remaining kW to our national level.

CHAPTER -1
INTRODUCTION

1.1Foundation:

"To bring modern energy services to people 170 million. In Bangladesh this year's consumption of energy. Of electric power per annual salary. This is averaging 332 kWh per annum. Bangladesh can provide itself with completely self-produced Energy

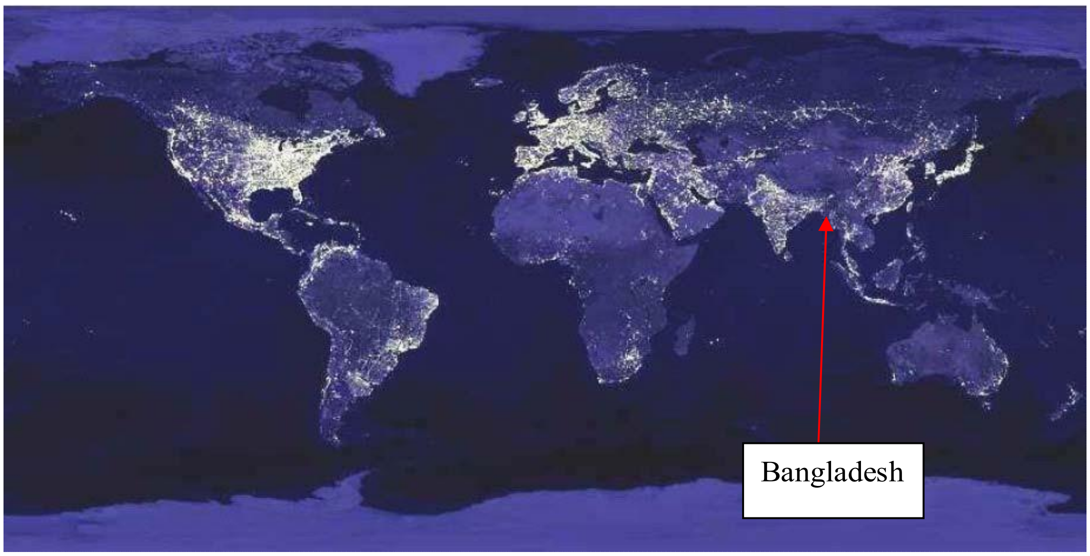


Figure 1.1: Global at Night (2020) [21]

Table 1.1: Access to Electricity and per Capita Consumption in South and South East Asia*[1][22]

Country	Electricity - consumption (billion kWh)	Year
China	5,564	2019
India	1,137	2019

Japan	944	2019
Russia	910	2019
Russia	910	2019
Korea, South	508	2019
Saudi Arabia	296	2019
Taiwan	237	2019
Iran	236	2019
Turkey	231	2019
Indonesia	213	2019
Thailand	188	2019
Vietnam	143	2019
Malaysia	137	2019
United Arab Emirates	113	2019
Kazakhstan	94	2019
Pakistan	92	2019
Philippines	78	2019
Kuwait	58	2019
Israel	55	2019
Bangladesh	54	2019
Uzbekistan	49	2019
Singapore	48	2019
Hong Kong	42	2019
Iraq	38	2019
Qatar	37	2019
Oman	29	2019
Bahrain	26	2019

Azerbaijan	20	2019
Jordan	17	2019
Lebanon	16	2019
Turkmenistan	15	2019
Burma	15	2019
Syria	14	2019
Korea, North	14	2019
Tajikistan	13	2019
Sri Lanka	13	2019
Georgia	12	2019
Kyrgyzstan	11	2019
Mongolia	6	2019
Cambodia	6	2019
Afghanistan	6	2019
Laos	5	2019
Armenia	5	2019
Macau	5	2019
Nepal	5	2019
Brunei	4	2019
Yemen	4	2019
Bhutan	2	2019
East Timor	0	2019

1.2 Energy sources:

Renewable energy sources and pro-Renewables Resources

Renewable: renewable energy, which are regenerated after a regular time cycle, are widely known as renewable energy sources such as hydroelectric power, wind , solar,

tidal, biomass, etc. Non-renewable: renewable energy formed over even a length of time and within earth's atmosphere.
Thousands of years are named non-renewable sources of energy; including coal, oil and natural gas. Individuals are deemed non-renewable since if deleted.
People are not replaced by the sea floor and also used.

1.3 Renewable Energy sources of Bangladesh

Bangladesh is gifted with a number of possible renewables, and solar, wind, liquid, biomass, and biogas are option funds.

Wind Energy

Wind energy is a form of renewable energy. Wind energy (or wind power) begins the act whereby the food is grown from wind. Wind turbines ac motion to the kinetic wind. Direct current may be used for certain tasks, such as water draining.

Hydro Energy

Bangladesh, becoming a flat nation, is never in a good position for hydropower of large scale. Mini and micro-hydropower capability is small in the CHT region and in greater Sylhet area. The country's total installed capacity at three sites (Kaptai, Sangu and Matamuhuri) is 1500 GWh / year (755 MW), of which about 1000 GWh / year (230 MW) was utilized at Kaptai via 5 hydropower plant units.[2]

Tidal power

Typically, an average arm of at at 5 meters is viewed the limit needed for feasible tidal energy production. Firstly, in Bangladesh there is far less chance of tidal asset. Embedded power plants may be usable in coasts.

Bio-gas

Country depends on agriculture Bangladesh has great promise to use clean energy. Biogas is a fuel gas achieved from anaerobic (i.e., without oxygen) cattle dung digestion, cattle dung, human excreta, and crop waste .Bangladesh is in a stable position as to the availability of raw materials and the climatic conditions for the biofuel production. Cost is the most dominant factor that also limits the wide use through biogas.

Solar Energy

The energy that the sun emits in the radiation is known as solar energy. The sun is a crass supply of free energy. The sun pours spills indescribable levels of fuel into space every day. Some are in the form ultraviolet light, but the large number are in the form of photons Any of that energy did fall on Earth, which also cools the layer of our comets, pulls sea currents, wind flows, trees use it to make food, etc. Moon-life totally depends on the heat.

Solar has brighter potential from a viewpoint comparison with any renewable resources. The moon acts as a major radiation emitter (Black body) for a decent estimate. The solar ablation at the outer edge of an air is defined as the solar radiation once the world is at its average sun.

$S = 1367\ W/m^2$

1.4 Objectives of the project

To introduce Renewable Energy (RE) as an alternative solution for power generation.
RETSCREEN calculation of solar home system.
Cost comparison of solar home system.

We can see here the calculation with retscreen software, in this calculation we are working with 100 kw and after getting the total cost with the rest of the transportation cost is done together, After doing that 100kw calculation, we connected 20 houses, before that we took out the cost of 20 houses per month. After that I can sell the remaining kW to our national level.

1.5 Project Target

Bangladesh is situated between 200 30 'and 260 45' north latitude and has a total surface region of 1.49E+ 11 m2. On average 5 kWh / m2 of solar radiation occurs for 300 days a year on this property.

Promote Solar Energy production and uses in Urban, Sub Urban, Rural, and Agriculture & Industrial Sector.

Reference of uninterrupted power supply.
Reference of surplus power transmission directly to grid line.

CHAPTER – 2
BACKGROUND OF THE STUDY

2.1 Country Background

General: The People's Republic of Bangladesh lies between $20^{0}34^{/}$ and $26^{0}38^{/}$ North latitude and between $88^{0}01^{/}$ and $92^{0}41^{/}$ East longitude. The country is bordered by India on the North and on the West, by the Bay of Bengal on the South, and by India and Myanmar on the East. The area of the country is 147,570 square kilometers. The map of the country is given in the Figure 2.1. It is mostly a low and flat deltaic land with the exception of some hilly areas in the North-east and South-east and some high lands in the North and North-east. The country is also one of the most natural hazard prone countries of the world and is visited regularly by floods and cyclones, and occasionally by droughts. [3]

Bangladesh is a country located in the heart of the Ganges-Brahmaputra-Delta in the south of the Asian continent. Bangladesh borders India on three frontiers: western, northern and eastern, southeastern Myanmar, and southern Bengal Bay.

The Republic of Bangladesh was founded in 1971,[7] whenever the Bengali-speaking population seceded from Western Pakistan as they were viewed back then as Pakistan's eastern province The child is basically one of the most countries affected each year as disasters hit more frequently. For example; tropical cyclones hit the coastal regions of the country about twice a year, both the rise in sea level and heavy flooding have accelerated the erosion of the river banks and the loss of arable land. Bangladesh also suffered prolonged heat waves recently, hence both natural disasters and environmental challenges have jeopardized the livelihoods of the Bangladeshi people, who rely mainly on agriculture.

Figure 2.1: Map of Bangladesh

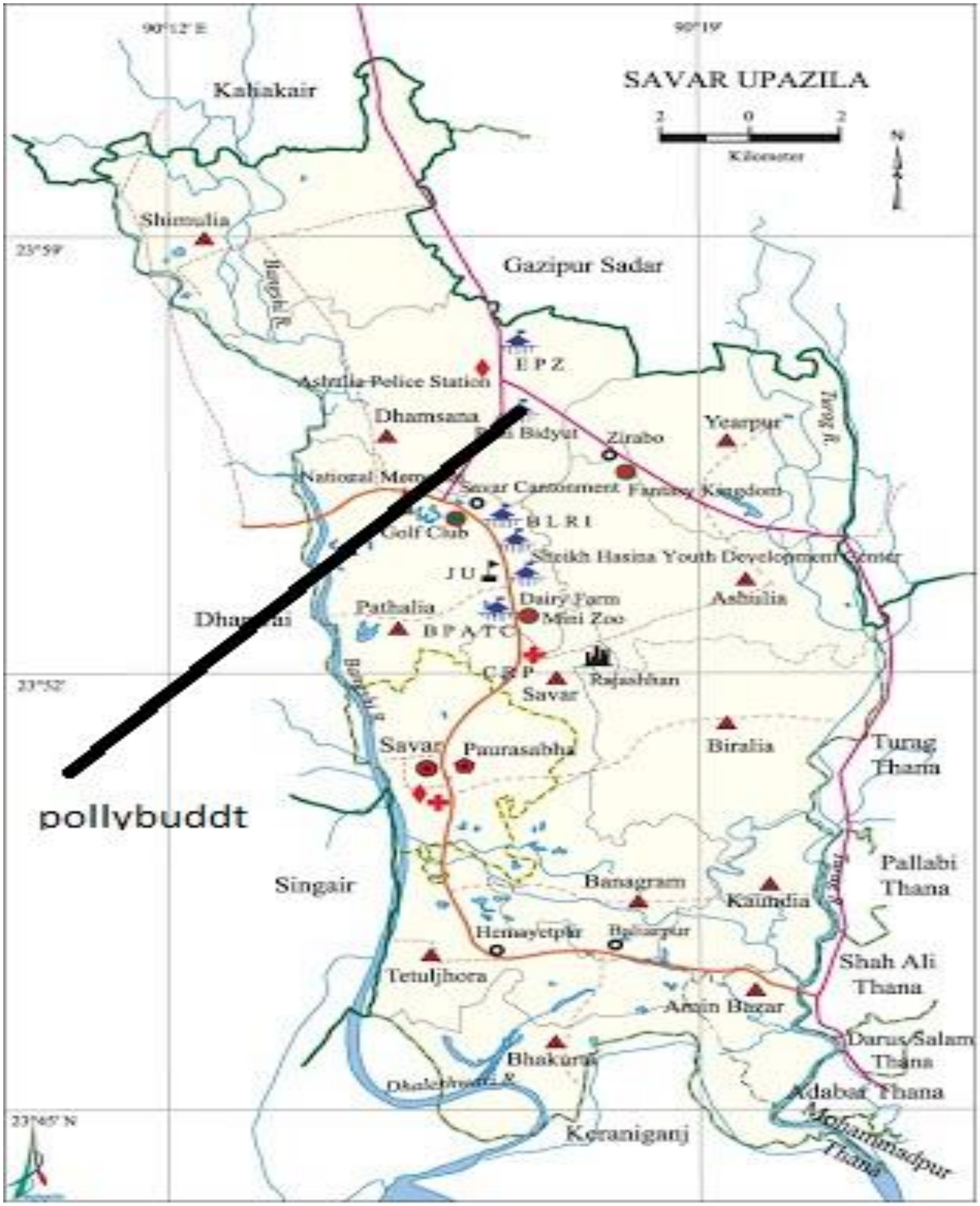


Figure 2.2: Map of Savar Area

Bangladesh is considered one of the fastest growing economies in the Southern-Asia, with 64% of the total population are living in rural areas by 2014, Bangladesh ranked as 9th in the world's largest populated countries

The country has a very limited energy reserve; small quantities of reserves for oil , coal and countable natural gas. The country suffers from an actual energy fight, as approximately 93 percent of the country's thermal power plants are fuel-based, but the gas is also required for the industrial sector. The country firstly has to -continuously- make sacrifices between energy production and the development.

Bangladesh is one of the world's poorest and most densely populated nations. The last Household Income and Expenditure Survey (2010) classified 32% (from 56.6% in 1990/91) of the country's population as "poor" (i.e. incomes below the upper poverty line of BDT 1311-2038, which is calculated on regional base - see graph below). 17% of the population is considered "extremely poor" having income below the lower poverty line. In rural areas, where more than 70% of the population lives, 35% are below the upper benchmark and 21% fall even below the lower regional poverty lines (BDT 1192-1495).

An average household in Bangladesh consists of 4.5 household members and have an overall income of BDT 9648, or about BDT 2130 per head. The average per capita income level of consumers below the upper poverty line is BDT1271 per month,[9] for those below the lower poverty line its only BDT 1102.84 per month on national level. According to the 2010 survey, the number of earners per household is 1.31 at national level, 1.27 in rural area and 1.40 in urban area. Since, 1995-96, number of earner per household shows a declining trend and has a positive correlation with the declining changing pattern of household size. The income per earner was found to be BDT 8795 for the country as a whole in 2010. In rural areas, this was BDT 7592 and in the urban BDT 11778. Income per earner increased to BDT 8795 in 2010 from BDT 5145 in 2005, an increase of BDT 3650 (70.94%) during this period. The average income per household in turn was found to be 9648tk in rural areas and 16477tk in urban areas, on a national level the average amounts to 11480tk.

In 2013, the International Renewable Energy Agency (IRENA) ranked Bangladesh as having the sixth-largest renewable energy–related workforce in the world with 114,000 jobs. [4]

Table 2.1:Socio-economic and Demographic Information

Indicators/Variables	2011	2004	1991
1. Household size (Dwelling)	4.35	4.66	5.5

2. Sanitary toilet facilities (%)	61.6	N/A	N/A
3.Sex ratio	99.68	104.1	106.26
4. Literacy (%)	47.68	38.06	24.90
5(a). Economic activity rate (Male) (%)	66	68.1	77.1
5(b). Economic activity rate (Female) (%)	9.8	5.4	6.7
6. Gross growth rate	1.08	1.26	1.66
7. Internal migration (rural to urban) (%)	4.29	4.79	5.62
8. International migration rate (%)	3.46	N/A	N/A

2.2 Energy Situation

Bangladesh's power sector is fossil fuels, as natural gas and coal are the main source of electric generation in the country. nearly 62.9% of Bangladesh's electricity based on natural gas, 10% from diesel, 5% from coal, 3% from heavy oil and 3.3% from energy power.[5]

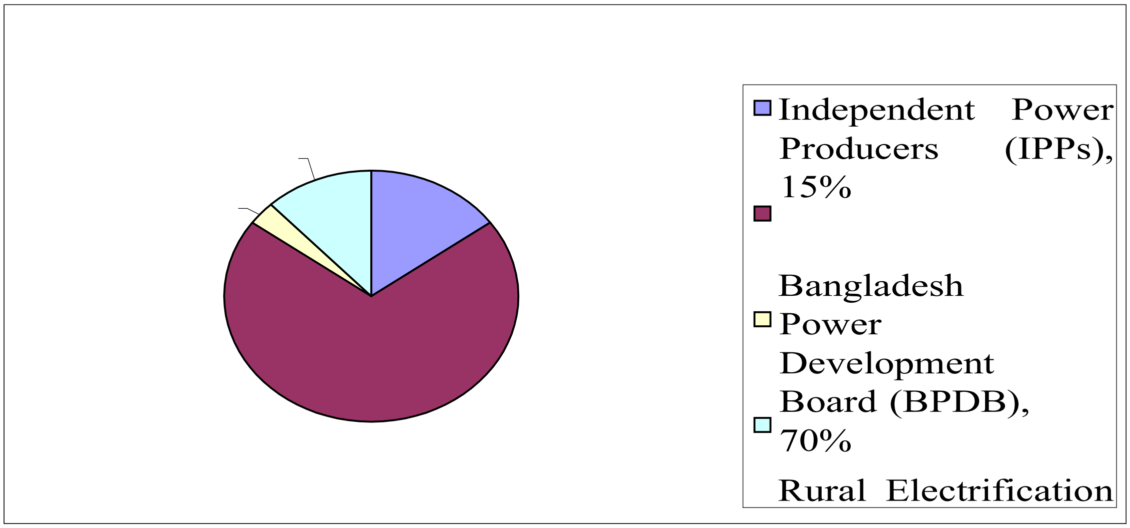
Spite of the fact that the energy sector in Bangladesh is using and covers an array of goods; energy, petroleum products, natural gas , coal, biomass and solar, policymakers and decision-makers are largely concerned with electricity, as it is the most popular type of power used in the country. As such, so there is an ongoing and growing fast gap for both demand and cost of electricity, [10]

In 2016, the total number of consumers connected to the grid is 21.8 million. Out of the 21.8 million, 16 million are domestic connections (households), which would represent roughly 50% of all Bangladeshi households (30-40 million). Another 15% of the households have access to off-grid electricity. [5]

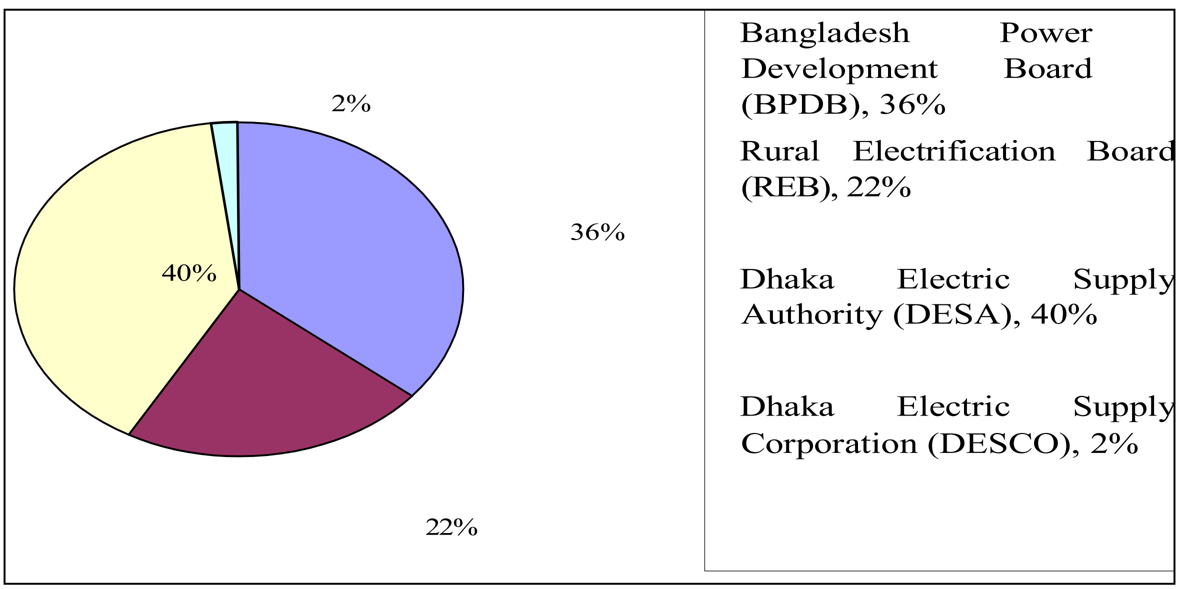
2.3 Power Generation and Distribution

Three government-owned enterprises, the Bangladesh Power Development Board (BPDB), the Rural Electrification Board (REB) and the Dhaka Electric Supply Authority (DESA) are currently in process of proving energy service to the Bangladesh population. BPDB and Independent Power Producers (IPP) generate mainly electricity.

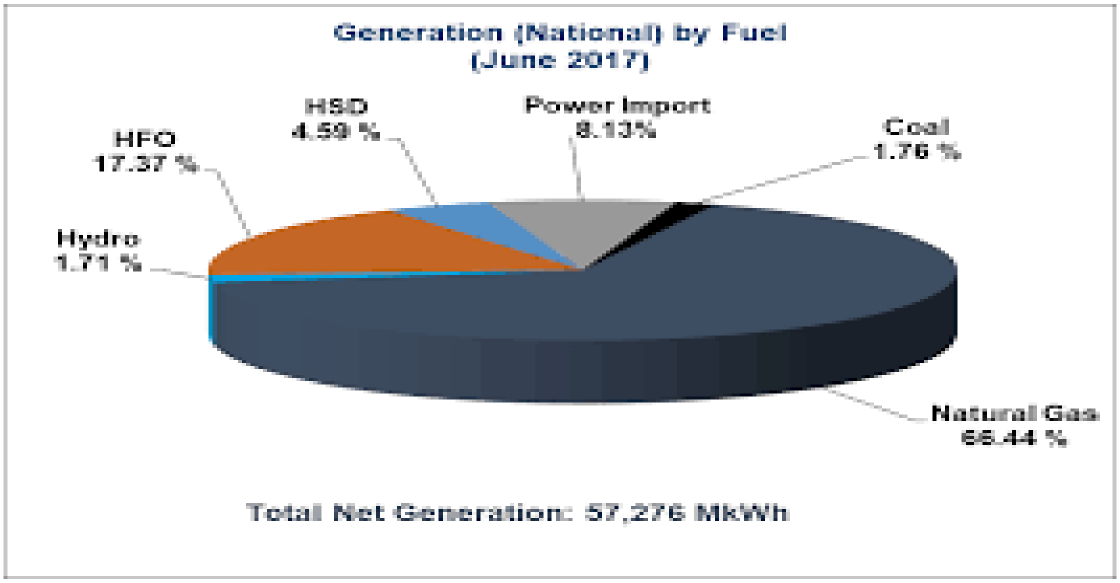
Chart 2.1: Generation Capacity by Institution in 2017[6][21]



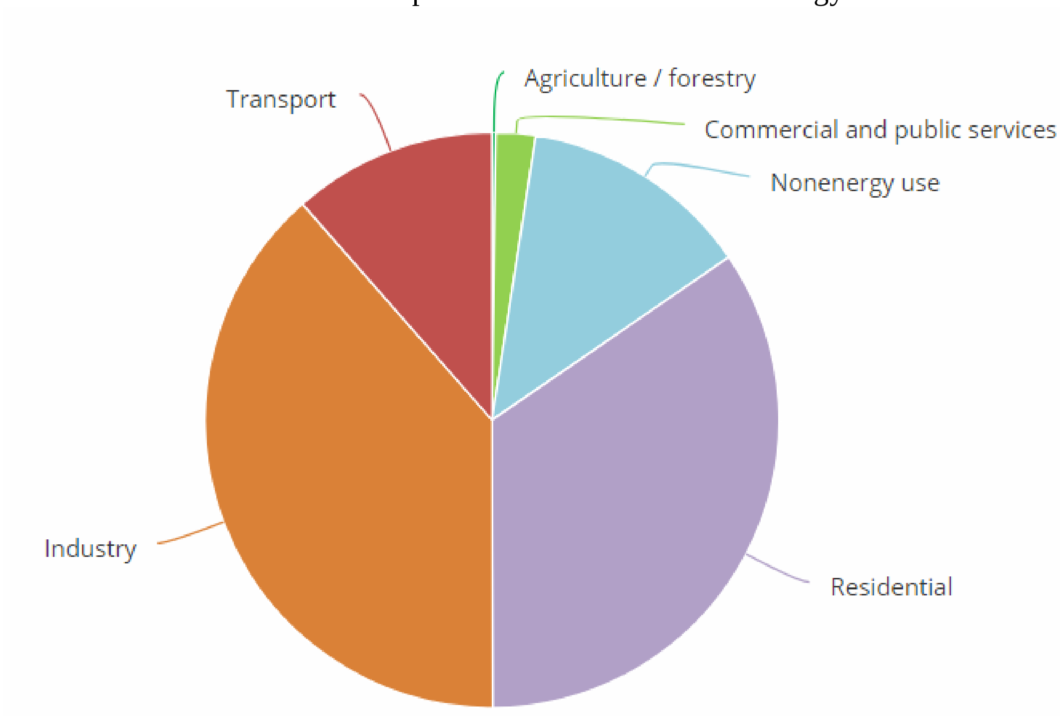
Electricity Distribution by Utility 2017



Total Installed Capacity



Sector Wise Final Consumption of Commercial Energy for the Financial



2.4 HISTORY OF RURAL ELECTRIFICATION IN BANGLADESH

Development plans of Bangladesh has identified rural electrification as one of the major components of overall infrastructure, implementation of which, it is held, can accelerate the pace of economic growth, employment generation, alleviation of poverty and improve living standard. A well planned and organizational rural electrification program was however, not existed till 1970s. The electrification program as carried out by the Bangladesh Power Development Board (BPDB)[19] was mainly limited to urban centers and at best to their peripheries. At that time, the Government of Bangladesh engaged two consulting firms of USA to carry out a comprehensive feasibility study on rural electrification in Bangladesh. The firms studied all related issues in depth and put forward recommendation towards a sustainable and viable rural electrification program. In addition to the new institutional framework, the study emphasized for Area Coverage and Co-operative concept. It is against this backdrop, Rural Electrification (REB) was created by the Government of Bangladesh (GOB) in late 1970's through REB ordinance LI of 1977.[7] The Board is a statutory Government organization primarily responsible for implementing countrywide rural electrification.

Since inception, BREB sets forth the following major objectives in implementing the rural electrification program. Ensure peoples participation in policy formulation in a democratic way. Provide reliable and sustainable electricity to the rural people at affordable price Improve economic condition of the rural people by using electricity in agriculture, cottage and agro based industry.

Improve living condition of rural peoples.

Bring about entire rural Bangladesh under RE program or an area coverage basis.

To achieve the objectives of rural electrification program at the implementation level, the Board established Palliy Bidyut Samities (PBS) [which means Rural Electric Societies in English Language] based on the model of Rural Electric Co-operatives in USA under the universal principle of co-operative, democratic decentralization and ownership of consumers. A PBS, which owns, operates and manages a rural distribution system within its area of jurisdiction is an autonomous organization registered with REB. The member consumers participate in policy making of PBS through elected representative to the PBS governing body known as Board of Directors.

Right from the establishment of a PBS, REB assists the PBSs with

Initial organizational activities.

Training of manpower.

Operational and management activities.

Procurement of funds.

Providing liaison between Bangladesh Power Development Board, Dhaka Electric Supply Authority (Bulk power supplies) and other concerned Government and Non-Government agencies.

Conducting election of PBS.

Central to the PBS system, the area coverage concept generally comprises 5-10 thanas having a geographical area ranging between1500-2000 sq. km. For each PBS load forecast is made for the next 20 years based on detailed study and accordingly load centers are set up in order to identify the location of the distribution Sub-Stations. The cost of the distribution system is given on a thirty three years term loan to the PBSs with first eight years as grace period with an interest rate of 3% per year. To maximize consumer welfare, the PBSs operate on the financial principle of "No-loss & No-profit" basis.

Rural electrification in a developing country like Bangladesh is a huge capital intensive program. In order to ensure the mobilization of fund and steady growth of the electrification program REB had taken a pragmatic plan to implement the gigantic task by phases. REB started functioning in early 1978 with the first project under the 1st phase undertaken for establishment of 13 PBSs in different parts of the country. Over the last twenty six years, more PBSs were organized in various phases which brings the current total at 70. The fifth phase of the Rural Electrification program is now under implementation. REB plans to cover all the village of Bangladesh by the year 2020 A.D.

Rural electrification in Bangladesh is often viewed as one of the most successful program and has also been credited both in the country as well as in international arena. Relatively low System loss in the range of 15% and high rate of bill collection nearly 100% is the achievement widely appreciated by the Development partners and International agencies.

This has been possible due to the unstinted and unflinching support that the Government of Bangladesh and our development partners have placed in the operation and philosophy of Rural Electrification. But given the huge task that lies ahead involving the total electrification of the country, there is no room for complacency as yet.

2.5 ROLE OF RE PROGRAM IN AGRICULTURE

The greatest result of Rural Electrification program has been achieved in the agricultural sector. The use of electric pumps for irrigation in the dry seasons (January-April) brought revolution in the food production culture.[8] Boro paddy produced in this dry period fully depends on irrigation from surface or underground water. Hand driven tube wells proved to be inadequate for large fields and diesel pumps are too expensive source of water. Diesel pumps need regular maintenance, skilled operators and mechanics are not readily available. This method of irrigation lost popularity in course of time and farmers showed reluctance to use diesel pumps. Comparatively

cheap irrigation of land is provided by electric pumps which need negligible maintenance.
As a result, popularity of electric irrigation pumps among farmers of Bangladesh has grown up in past years. With less than 2000 electric pumps in 1981-82[13] Fiscal Year, the number of pumps come under electrification has increased tremendously exceeding 2, 38,281 up to January, and 2017. The role of Rural Electrification Board and GOB in popularizing electric pumps in agricultural sector was very important. Although tariff of all other categories of consumers has gone up over a period of time, tariff for irrigation consumption remains almost same for last five years. It enables the farmers to keep cost of production low and price of products competitive in the market.

Table 2.2: The followings are the main features of rural electrification in Bangladesh as on January 2017. [9

Number of PBSs organized	78
Number of PBSs operating commercially	78
Number of district under the program	61
Number of Up-Zillas under the program	453
Number of villages electrified	65,579
Total distribution line constructed	3,30,728 Km
Total distribution line energized	3,07,408 Km
Total 33/11 KV sub-stations constructed and commissioned	767 (591 Constructed by BREB, 87 Constructed by Private, 89 taken over from PDB/DPDC/OTHERS)
Installed Capacity of Sub-stations	8402 MVA
Total number of consumers	1,73,92,712
Total number of irrigation pumps connected	2,38,281
System Loss	11.74% (cumulative),9.59% (Jan'2017)

2.6 FUTURE PLANS

According to the 1991 census, number of villages in Bangladesh is 86038, out of which about 75000 villages have been planned to be brought under RE program. Remaining villages constitute the areas presently covered by BPDB/DESA and the Chittagong Hill 2Tract Districts where RE Program has not yet been considered for implementation.

It is the ultimate goal to bring all the villages of Bangladesh under electrification by the year 2020. Under the RE program, which started in 1980, about 45% villages have already been brought under electrification by 2005. [14]The mid-term plan is to cover further 20% villages by 2005 and remaining villages to be covered by 2020 under the long term-plan.

2.7 Renewable Energy Policy

NEP has recommended the establishment of Renewable Energy Development Agency (REDA) to accelerate the growth of the country's renewable energy sector. Until REDA is formed Power Cell will perform all primary and initial work related to renewable energy development.[10]

REDA Responsibilities Act as a center in Bangladesh's energy industry and portray nation in global renewable energy development institutions

Take mortar steps to eliminate the national current, institutional, economic, market, data, technical and social service obstacles.

Evaluate the production from renewable initiatives that may directly contribute to power needs in both short term and the long.

Establish a slush fund for renewables to fund energy projects and R&d.Collect discount cash for energy projects from bilateral creditors to be enforced via Community-based organizations (CBOs), NGOs and rural water innovators.

Convey and oversee the implementation of renewable energy and help the content area (BOI) in facilitating foreign and local investment;

Draw up a funding and distribution method to create renewable energies more affordable for rural population.

Improve access to adequate health care in the semi-electrified areas renewable energies in health centers and by publicizing use of clean energy in virus or vaccination initiatives.

Improve the quality of education in the un-electrified areas through the provision of renewable energy systems in schools.

Promoting use of sustainable power to enhance clean water entry; Establish renewable energy powered Information and Communication Technologies (ICT) center in the off-grid areas.

Arrange required training programs for capacity building and technology transfer needed to support commercialization of renewable energy technologies (RETs)

CHAPTER – 3
Benefits of Solar PV

3.1 Introduction:

Currently, the burning issue around the world is the effect of global warming and climate change. Bangladesh will also be the country greatest impacted by the effects of global warming around the country. Effects for warming are so many. The most noteworthy of these is power generation. Without power (Electricity) we cannot think about any development. It will be finished in the short time if we use them in the present rate. So there is no other way of thinking about environmentally friendly sources of renewable energy production.[11] Solar energy is the most effective source of renewable energy production in the Bangladesh context. Even if fuel is available within the country, it can be difficult to transport that fuel to the remote rural village. In many remote villages, where animal transport is still common, there are no loads or supporting infrastructures. For example, transportation by animals limits the capacity of loads and some loads, diesel generators may not be able to bring them to such locations. In many developing countries the use of renewable energy is attractive for the use of solar energy. . The solar radiation energy is converted into DC power and it requires an AC power inverter. But there are still some problems which make it uncomfortable for us. Its efficiency is very low, and its energy prices are still so high.
So we're trying to find ways to make it comfortable in this paper. [15]

3.2 Solar energy attractive in Bangladesh

In Bangladesh, insolation varies from 3.8 kWh / m2 / day to 6.4 kWh / m2 / day at an average of 5 kWh / m2 / day. These indicate that the solar thermal and photovoltaic prospects are good
Application nationwide. [12]

3.3 Important uses of solar power

Source of Conventional Energy is Limited.
Production of power from conventional Energy causes CO Emission.
Easy to install and use
Noise free.
Less maintenance.
Source is unlimited.
There is no moving part, so its life is long

3.4Potential of solar energy

Bangladesh is situated between 200 30 'and 260 45' north latitude and has a total surface region of 1.49E+ 11 m2. On average 5 kWh / m2 of solar radiation occurs for 300 days a year on this property. [12]

Table 3.1 Top ten countries using solar power
(_https://en.wikipedia.org/wiki/Solar_power_by_country)

Solar PV capacity by country (MW) and share of total electricity consumption [view/edit]

	2015		2016		2017		2018		Share of total consumption [1]
Country	**Added**	**Total**	**Added**	**Total**	**Added**	**Total**	**Added**	**Total**	
China	15,150	43,530	34,540	78,070	53,000	131,000	45,000	175,018	3.3% (2018)
European Union	7,230	94,570		101,433		107,150	8,300	115,234	4.3% (2018)[1]
United States	7,300	25,620	14,730	40,300	10,600	51,000	10,600	62,200	2.3% (2018)
Japan	11,000	34,410	8,600	42,750	7,000	49,000	6,500	55,500	6.8% (2018)

Solar PV capacity by country (MW) and share of total electricity consumption [view/edit]

	2015		2016		2017		2018		Share of total consumption[1]
Country	**Added**	**Total**	**Added**	**Total**	**Added**	**Total**	**Added**	**Total**	
Germany	1,450	39,700	1,520	41,220	1,800	42,000	3,000	45,930	7.9% (2018)
India	2,000	5,050	3,970	9,010	9,100	18,300	10,800	26,869	5.4% (2018)
Italy	300	18,920	373	19,279	409	19,700		20,120	7.3% (2018)
United Kingdom	3,510	8,780	1,970	11,630	900	12,700		13,108	3.9% (2018
Australia	935	5,070	839	5,900	1,250	7,200	3,800	11,300	6.3% (2018)
France	879	6,580	559	7,130	875	8,000		9,483	2.2% (2018)
South Korea	1,010	3,430	850	4,350	1,200	5,600	2,000	7,862	2.2% (2018)

Table 3.2: PV Systems in the REB Pilot Project [13]

Type	Stand-alone System				Charging Station-based System	
	System I	System IV	System V	Health Centre	System II	System III
Units Supplied	115	146	129	1	367	37
Module (Wp)	6 x 2	46	2 x 46	16 x 46	Charged at PV charging station	Charged at PV charging station
Battery (no. x volts x amp hours)	2x6x3.2	12x100	2x12x100	24x400	12x60	2x12x60
8 W Fluorescent	1	2	1	1	2	2
3 W Fluorescent	1	-	-	-	-	-
13 W Fluorescent		1	2	2	-	1
Fan		1	1	2	-	1
Socket	-	1	1	2	1	1
Refrigerator	-	-	-	1	-	-
Tariff (Deposit & Monthly Fee)	250 & 50	2500 & 175	3500 & 210	-	500 & 100	1000 & 165

Table 3.3 Status of Solar Home Systems Installation [15]

Partner organization	Number of SHSs installed
Grameen Shakti	795 957
RSF	216 434
BRAC	77 019
Srizony Bangladesh	58 927

Hilful Fuzul Samaj Kallyan Sangstha	37 078
UBOMUS	25 234
BRIDGE	20 449
Integrated development foundation	14 238
TMSS	13 059
PDBF	10 672
SEF	21 720
AVA	12 817
DESHA	10 931
BGEF	16 995
RDF	20 027
Others	77 883
Total	1 429 440

Division	**Number of SHSs Installed**
Barisal	265 320
Chittagong	278 730

Dhaka	374 587
Khulna	158 409
Rajshahi	200 480
Sylhet	151 914
Total	1 429 440

3.5 Application of Solar PV

The produced electricity can be used for lighting purposes and to power household appliances. The surplus power will be sold directly through the grid. Individual solar PV modules can be used in remote and rural areas for driving torches, flashlights, wrist watches etc. Rural market, mosque, school, health clinic and cyclone center. Information and communication technology training [7]

Micro enterprise (grocery shops, tailoring shops, restaurants, sawmills, rice mills, cellular phone service, barber shops) electrification Water pumping, remote telecommunication, etc. Solar Home Systems Market Potential in Bangladesh

3.6 The market potential of solar PV in Bangladesh lies in the following areas:

Remote/inaccessible rural area.

River island/offshore islands [10]

Areas that have a very 'thin load' of potential consumers

Areas that are far away from the present conventional grids and where the grid is not expected to reach in foreseeable future

Areas which are separated from a grid area by natural barriers, i.e. mountains, rivers etc.

CHAPTER – 4

Solar Energy in Bangladesh

4 .1 Physical Perspective of Renewable Energy in Bangladesh

As of July 2020, the power supply sector in Bangladesh has a national grid of 23,548 MW installed capacity. Total capacity installed is 23,548MW (solar power combination). The energy industry is booming in Bangladesh. The 2,4 giga watt (GW) Rooppur nuclear plant is expected to start operation in 2023, which has recently commenced construction in Bangladesh. In July 2018, 90 percent of population had access to electricity, according to the Bangladesh Power Development Board. In Bangladesh, however, energy per capita is considered low [10]

For most of the country's economic activities, electricity is the major source of power. Total installed power source in Bangladesh.

Industries and residential industries and the commercial and agricultural industries followed by the largest energy consumers in Bangladesh

Just since 2015, energy was available to 92% of the urban population and to 67% of the rural population. In Bangladesh, an average of 77.9 per cent of the people had electricity connection. Bangladesh's economic development would hit an approximate 34,000 MW by 2030.

The nation has the capacity to generate a cumulative 3,6GW of electricity from renewable energy, according to the Bangladesh Power Sector Master Plan 2016 (PSMP–2016). Another study estimated that the wind power potential alone amounts to 20 GW..[15]

Bangladesh has 15 MW of solar power in rural households, while in Kutubdia and Feni, there is 1.9 MW of winter power. The Government of Bangladesh has recently approved the construction of a private power plant in Teknaf, Cox's Bazar, which is equipped with 19 grid solar parks with an annual cumulative generating capacity of 1070 MW. This accounts for over 5% of the country's overall demand for power production from renewable energy sources. This energy plant, using a total of 116 acres, was installed in Teknaf by Technical Solartech Energy Ltd (TSEL). The power plant already supplies 20MW.

Here we see that It was found according to our software location

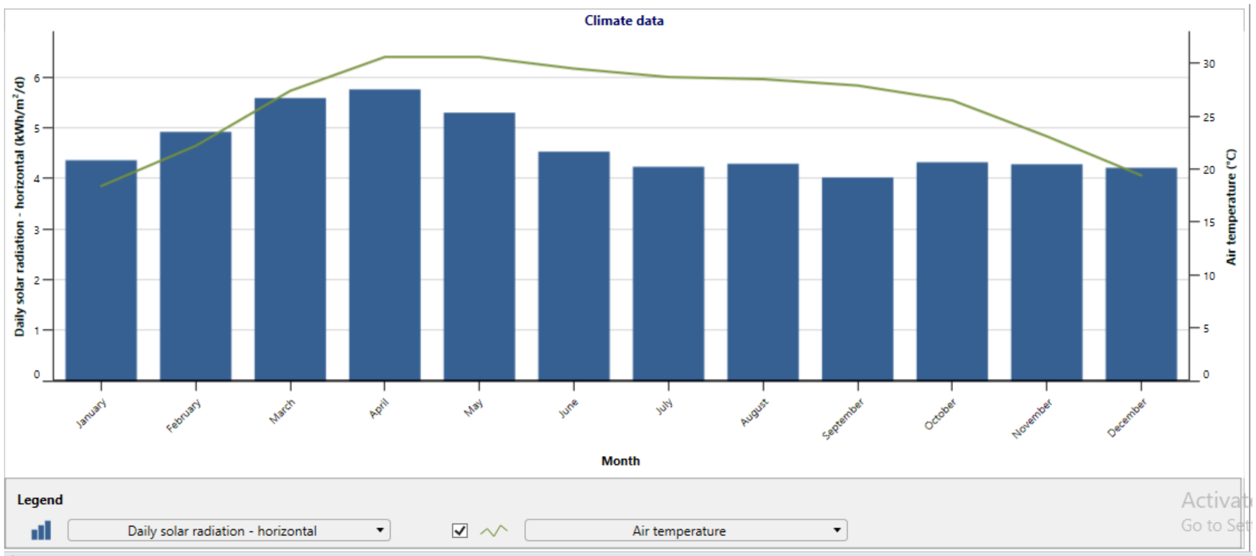


Fig: 4.1: average solar radiation in six divisions and average cloud coverage in six divisions.

The subtropical monsoon climate in Bangladesh is characterized by large seasonal variations in precipitation, high temperatures, and humidity. Bangladesh has three separate seasons: from March to June, a hot, humid summer; from June to October, a cold,rainy monsoon season; and from October to March, a cool , dry winter.

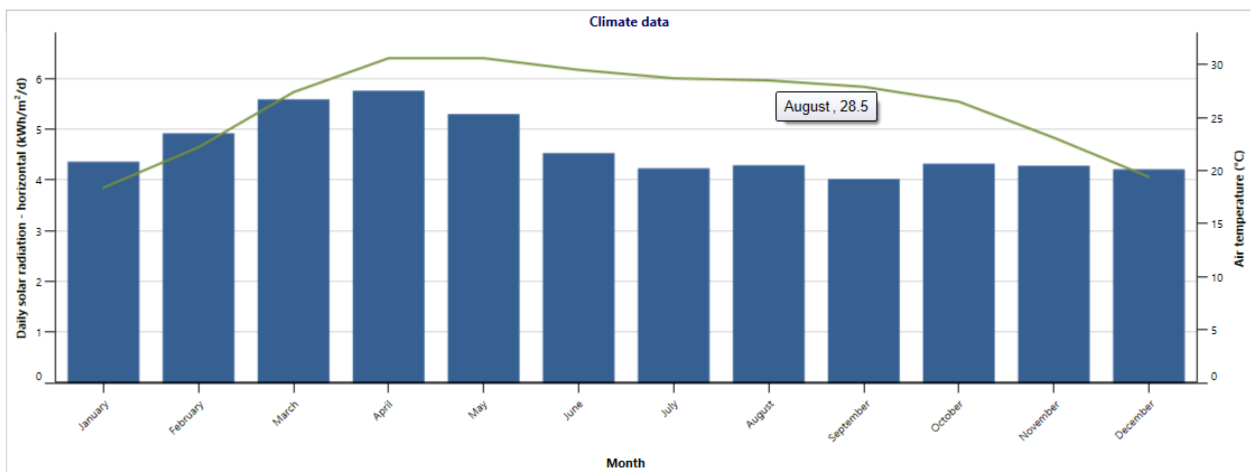


Fig 4.1.2: Monthly Average

	Unit	Climate data location	Facility location	Source
Latitude		23.7	23.9	
Longitude		90.4	90.3	
Climate zone		1A - Very hot - Humid		NASA
Elevation	m	9	14	NASA – Map
Heating design temperature	°C	14.6		NASA
Cooling design temperature	°C	31.6		NASA
Earth temperature amplitude	°C	14.2		NASA

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	18.4	51.6%	5.58	4.36	101.4	2.5	18.1	0	260
February	22.2	42.6%	13.16	4.92	101.2	2.5	22.2	0	342
March	27.4	40.0%	31.93	5.59	100.8	2.8	28.0	0	539
April	30.6	51.9%	84.90	5.76	100.6	3.6	31.8	0	618
May	30.6	65.3%	182.28	5.30	100.3	3.8	31.6	0	639
June	29.5	79.4%	233.70	4.53	99.9	4.3	30.0	0	585
July	28.7	85.1%	256.06	4.23	100.0	4.3	29.0	0	580
August	28.5	85.6%	218.86	4.29	100.1	3.7	28.8	0	574
September	27.9	85.3%	197.40	4.02	100.4	3.0	28.1	0	537
October	26.5	77.9%	118.73	4.32	100.8	2.2	26.6	0	512
November	23.1	68.4%	21.30	4.28	101.2	2.1	22.9	0	393
December	19.4	61.8%	8.06	4.21	101.4	2.2	19.0	0	291
Annual	**26.1**	**66.4%**	**1,371.96**	**4.65**	**100.7**	**3.1**	**26.4**	**0**	**5,869**
Source	NASA	NASA	NASA	NASA	NASA	NASA	NASA	NASA	NASA
Measured at					m	10	0		

The tropical monsoon climate in Bangladesh is characterized by large seasonal rainfall variations, high temperatures, and high humidity. In this flat country, regional climatic variations are slight. In general, summer high temperatures range between 100.4 and 105.8 ° F (38 and 41 ° C)

Fig 4.1.3: climate

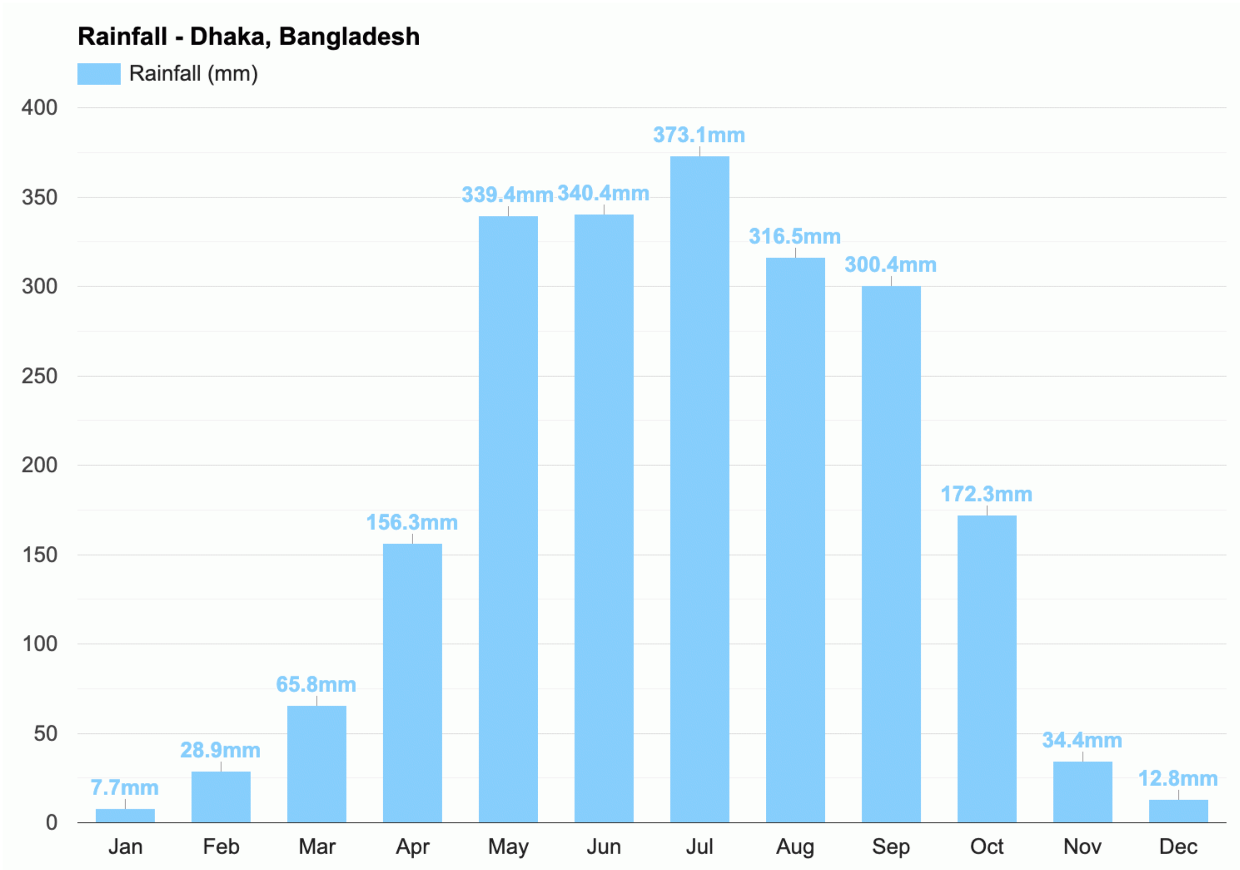


Fig 4.2: Average sunlight hour in six divisions over three years.

The duration of sunshine or sunshine hours is a climatological measurement that measures the duration of sunshine over a given period (usually one day or one year) for a given place on the planet, generally expressed over many years as an average value. It is a general predictor of a location's cloudiness, and therefore varies from insolation, which measures the cumulative energy that sunlight provides over a specified period of time.

Usually, the amount of sunshine is expressed in hours per year, or in (average) hours per day. Compared to other locations, the first calculation demonstrates the general sunniness of a region, while the other allows the contrast of sunlight in different seasons in the same region.

The characterization of the climate of sites , especially of health resorts, is an important use of sunshine duration data. It also takes into consideration the psychological effects on human well-being of direct solar radiation. To support tourist attractions, it is also used

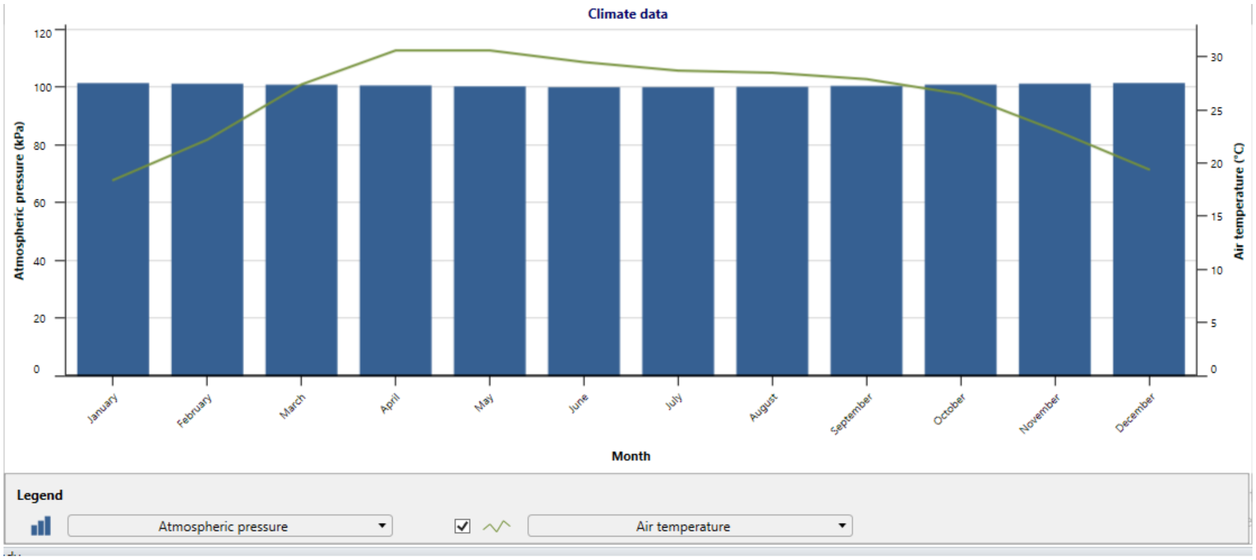


Fig 4.3: Atmospheric pressure

4.2 Present Status of Solar Energy in Bangladesh:

As we said, just half of the population of Bangladesh is electricity connection from the national network. Carbon energy sources accounts for about every 5,500 MW of current output, with a contribution of just 55 MW from renewable energies – primarily solar power. Therefore, for Bangladesh, solar energy has huge potential. The socio-economic and industrial advancement in Bangladesh is hindered by energy ineptitude. The amount of energy produced by renewable sources accounts for about 560 Megawatt (MW) of electricity output of 20,430 MW. This paper summarizes Bangladesh's current energy situation and examines the renewable energy usable. [16]

4.3 Government program

The installation of solar panels has been deemed 'authorized growth' after law was amended in April 2008, and thus building permits IS NOT necessary. [17]

Our Limitations:

The construction of solar power plants needs substantial machinery and facilities. This needs an enormous sum of capital that most international investors would have to invest..

In this nation, most families (especially in rural areas) do not even have the ability to afford solar cells for their homes. Bangladesh also did lack the technologies and raw materials required to produce photovoltaic cells (PV), headlamps and other auxiliary products that must all be manufactured.

Maintenance and repair will also be a problem because technicians in this sector lack experience.

Hundreds of hectares of land are required for a solar power plant to construct, with normal adverse environmental consequences.

Protection is also an problem, because PVS are very costly and would possibly be stolen from the roof of a house, streetlights and other public installations at the first opportunity.

During winter and occasionally during the monsoon, cloud cover increases drastically, reducing the availability of sunlight and could thus affect the system of generation..

All our country’s limitations aside, photovoltaic cells have a very low efficiency.

Possible remedies and concluding remarks

Global knowledge can be created first of all by television awareness-raising campaigns like talk shows and workshops, in particular in educational institutions that empower young people.

Reduced taxes and any duty on essential accessories in that sector could contribute to a reasonable decline in costs.

Experts from countries notably concerned with progress in the solar sector could arrange training programs.

Government should offer financial rewards, service programs, offer technological and juridical assistance and subsidize even solar industry organizations.

CHAPTER – 5

Design and Analysis of a Stand-alone PV system

5.1 Introduction

The modeling of a photovoltaic device is a vital piece, namely a take-alone one. The dimension of a device include awareness of the site's solar radiation details, the load profile and the meaning of full compatibility. The sizing procedure instead specifies the photovoltaic generator size and the battery power to be suitable for operation. Because the amount of capital hardware is the key part of solar power prices, size of the plant is extremely harmful for the cost of gasoline generated. On the other hand, the size of a stand-alone system reduces the reliability of supply.

5.2 Design parameter and important assumptions for design and analysis

For this project, where grid electricity is available but not continuous, the project is located in BREB East Dandabor Savar Dhaka. This means that there is load shed. To optimize annual energy output, the pitch will be chosen. The high quality mono-crystalline-si PV array feeds the output of a charging device or an inverter into the mini grid.[18][11][9]

Therefore, important assumptions for the PVsyst and RETScreen technical and financial analysis for stand-alone system (SHS or PV-mini-grid) feasibility studies are as follows:

Here we are working with satellite view according to the location of the software

Location : East Dandabor Savar Dhaka

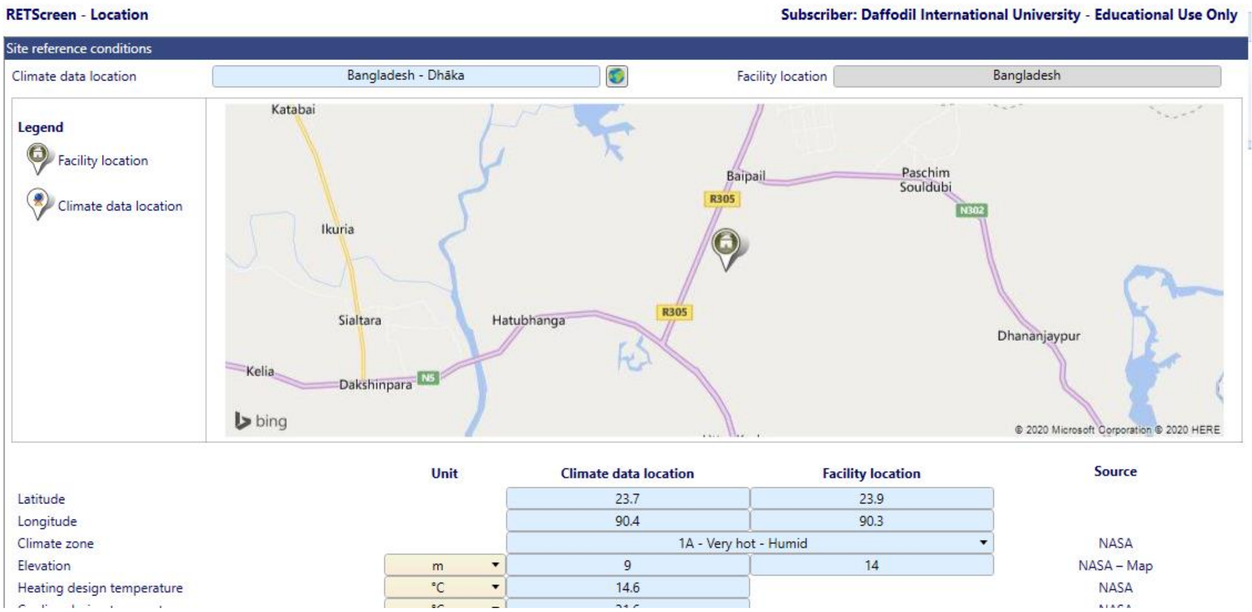


Fig 5.1 Location View :

Fig 5.2 Satellite view:

What you need is a browser for the web and an internet connection. Google Maps shows a satellite view of Bangladesh when you first boot up. You can then zoom in to see every location on Earth, or pan the camera around. You'll get a free satellite view of your house if you do so.

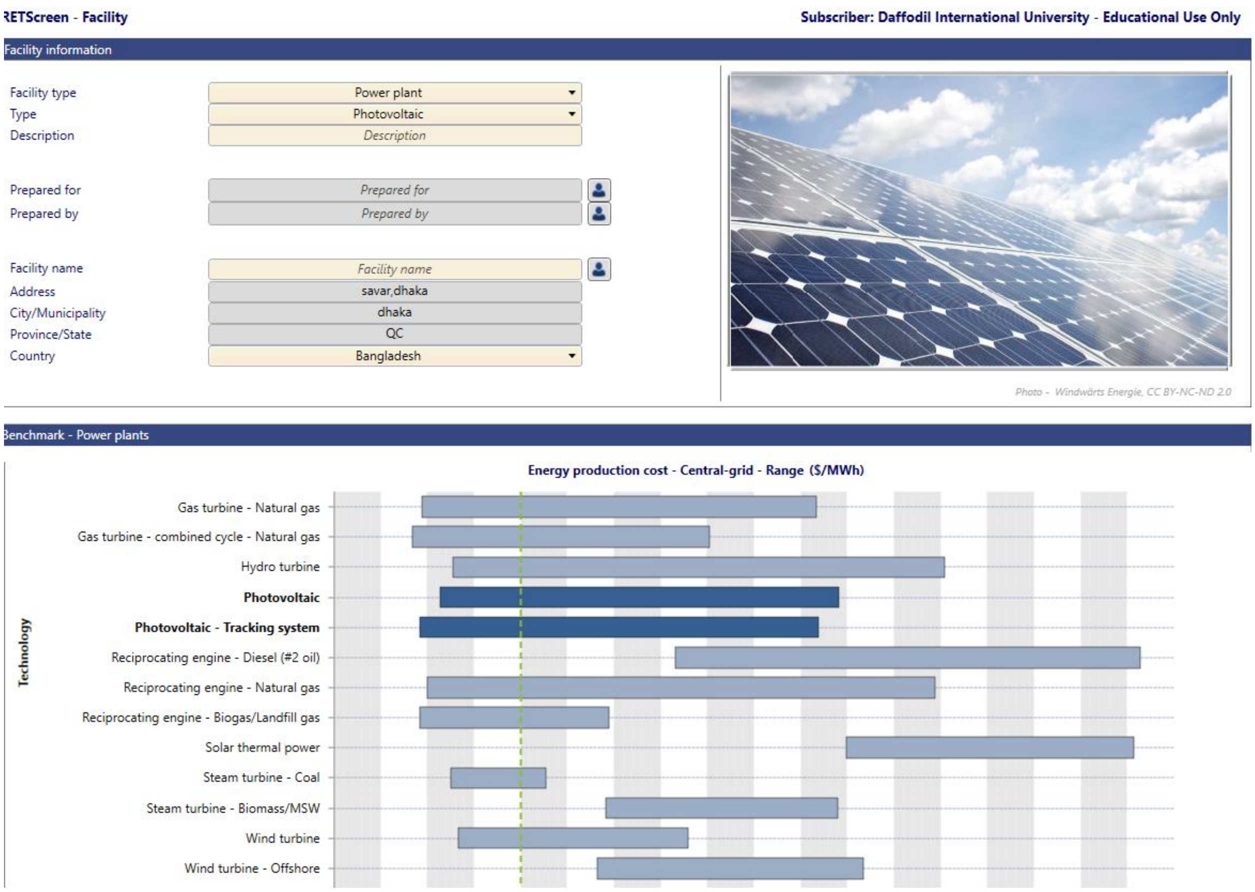


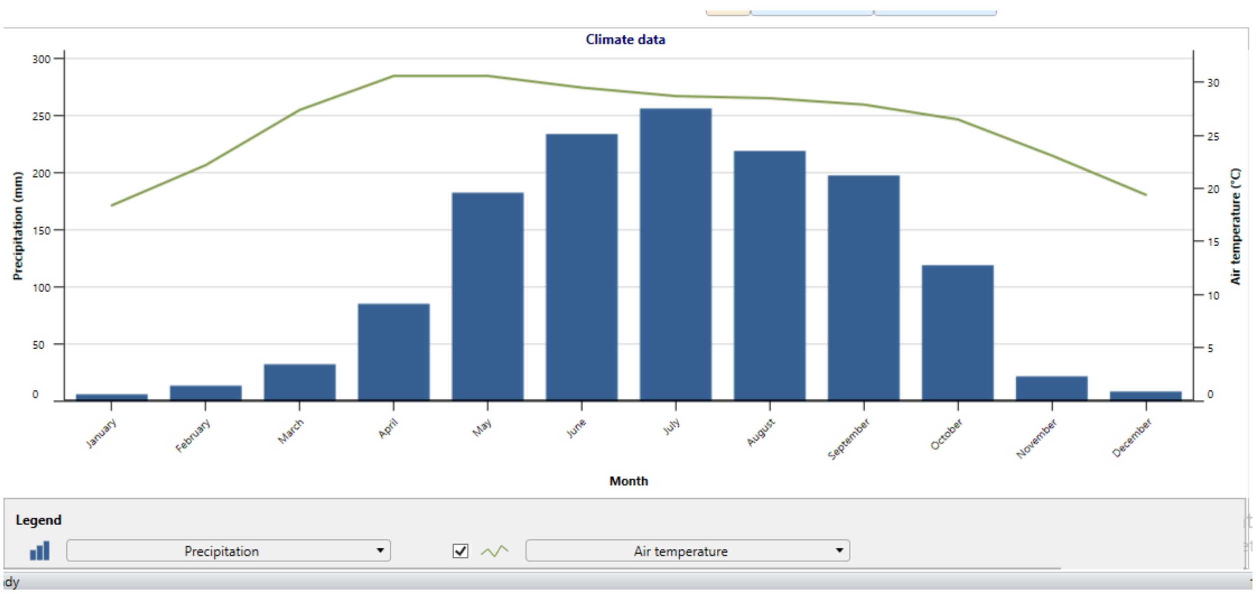
Fig: Range and setup for RET screen view

Climatic condition:

Climatic condition is one of the major factors for the slyness index, which leads the insolation. It is absorbed that the insolation is lowest in July but sometimes, in northern districts no sunshine day's goes to 10-15 days [18] in winter, which should not be taken wider consideration for designing solar system. In Bangladesh, normal practice for counting no sunshine days is 3, which is use for designing the battery autonomy

Temperature factor (T_r):

Standard practice for designing the life of panel is 20-30 years. The panel supplies 80% of its capacity for 20 years. When the panel absorbs solar radiation, the temperature increased nearly double than the environmental temperature. As the cell temperature increases, molecular vibration increases, cell voltage increases but the panel life decreases. To get the benefit from the system for the whole panel life, the panel size should be increased by 5 %. [13]



	Unit	Climate data location	Facility location	Source
Latitude		23.7	23.9	
Longitude		90.4	90.3	
Climate zone		1A - Very hot - Humid		NASA
Elevation	m	9	14	NASA – Map
Heating design temperature	°C	14.6		NASA
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Earth temperature amplitude	°C	14.2		NASA

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	18.4	51.6%	5.58	4.36	101.4	2.5	18.1	0	260
February	22.2	42.6%	13.16	4.92	101.2	2.5	22.2	0	342
March	27.4	40.0%	31.93	5.59	100.8	2.8	28.0	0	539
April	30.6	51.9%	84.90	5.76	100.6	3.6	31.8	0	618
May	30.6	65.3%	182.28	5.30	100.3	3.8	31.6	0	639
June	29.5	79.4%	233.70	4.53	99.9	4.3	30.0	0	585
July	28.7	85.1%	256.06	4.23	100.0	4.3	29.0	0	580
August	28.5	85.6%	218.86	4.29	100.1	3.7	28.8	0	574
September	27.9	85.3%	197.40	4.02	100.4	3.0	28.1	0	537
October	26.5	77.9%	118.73	4.32	100.8	2.2	26.6	0	512
November	23.1	68.4%	21.30	4.28	101.2	2.1	22.9	0	393
December	19.4	61.8%	8.06	4.21	101.4	2.2	19.0	0	291
Annual	**26.1**	**66.4%**	**1,371.96**	**4.65**	**100.7**	**3.1**	**26.4**	**0**	**5,869**
Source	NASA	NASA	NASA	NASA	NASA	NASA	NASA	NASA	NASA
Measured at					m	10	0		

RETScreen - Benchmark database - Power plants

Units $/kWh

Energy production cost - Central-grid - Range ($/kWh)			Key assumptions (Minimum | Maximum)			
Technology	**Minimum (Typical)**	**Maximum (Typical)**	**Capacity (kW)**		**Fuel rate | Capacity factor (%)**	
Gas turbine - Natural gas	0.048	0.259	1,000,000	100,000	0.10 $/m³	0.80 $/m³
Gas turbine - combined cycle - Natural gas	0.042	0.202	1,000,000	100,000	0.10 $/m³	0.80 $/m³
Hydro turbine	0.064	0.328	1,000,000	100	75%	25%
Photovoltaic	0.057	0.271	1,000,000	10	22%	13%
Photovoltaic - Tracking system	0.046	0.260	1,000,000	10	30%	17%
Reciprocating engine - Diesel (#2 oil)	0.183	0.432	100,000	1,000	0.60 $/L	1.20 $/L
Reciprocating engine - Natural gas	0.051	0.322	100,000	1,000	0.10 $/m³	0.80 $/m³
Reciprocating engine - Biogas/Landfill gas	0.047	0.148	100,000	10	0.0 $/m³	0.0 $/m³
Solar thermal power	0.275	0.429	1,000,000	10,000	30%	20%
Steam turbine - Coal	0.063	0.114	1,000,000	100,000	11.5 $/t	115 $/t
Steam turbine - Biomass/Municipal solid waste	0.146	0.270	100,000	1,000	0.5 $/t	50 $/t
Wind turbine	0.067	0.190	1,000,000	1,000	43%	12%
Wind turbine - Offshore	0.141	0.284	1,000,800	10,800	48%	33%

General assumptions:

Note: Typical cost values in Canadian $ as of January 1, 2019.

Purchasing power parity (Exchange rate) approximately 1.25 CAD = 1 USD.

Higher heating value (HHV), Inflation rate 2%, Fuel cost escalation rate 2%, Discount rate 9%, Project life: 20 yrs, Debt ratio 70%, Debt interest rate 7%, Debt term: 15 yrs, Income tax analysis: No

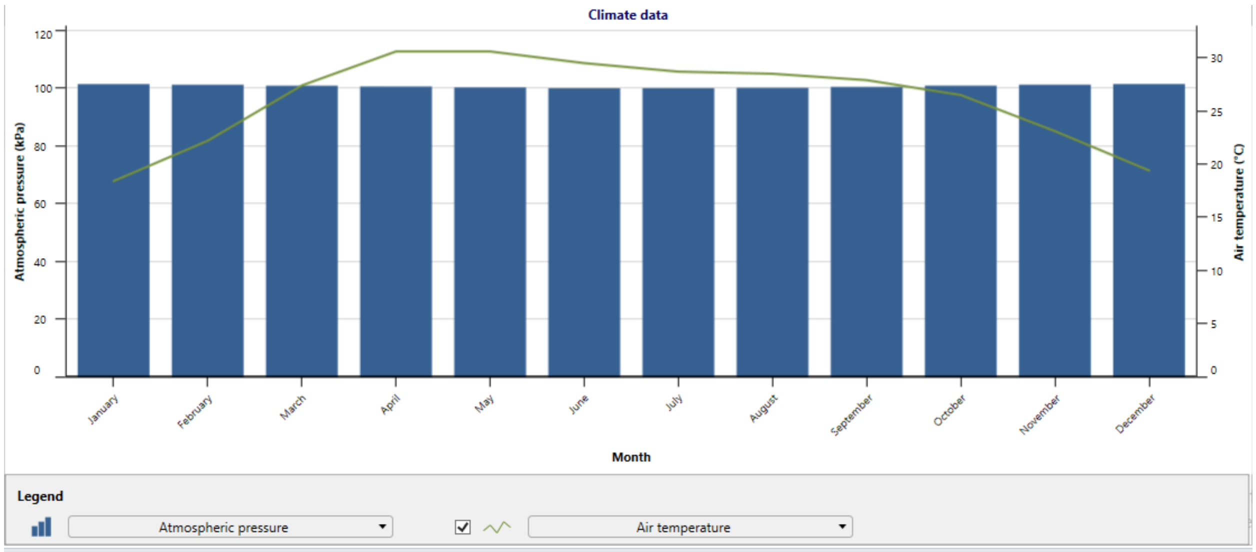
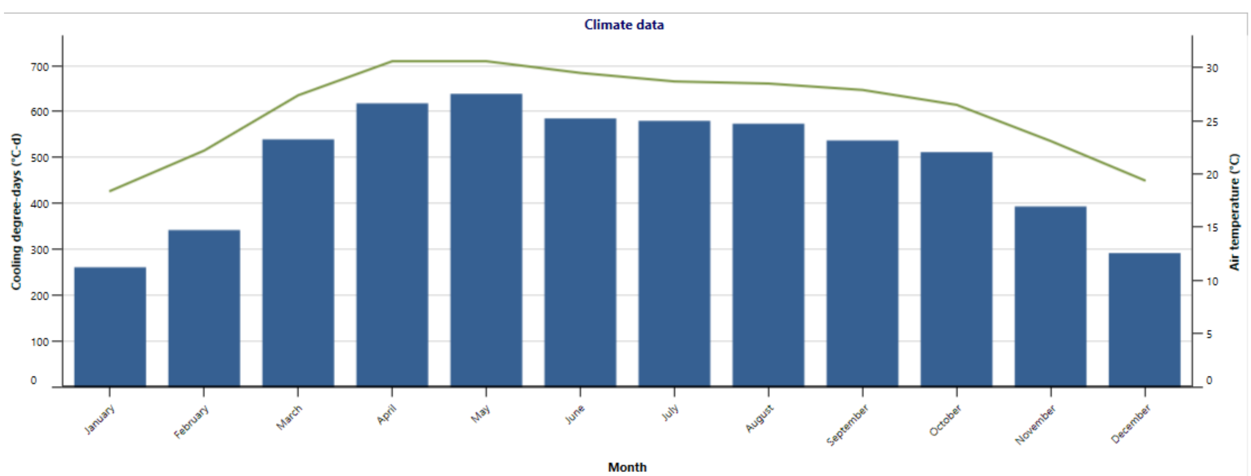
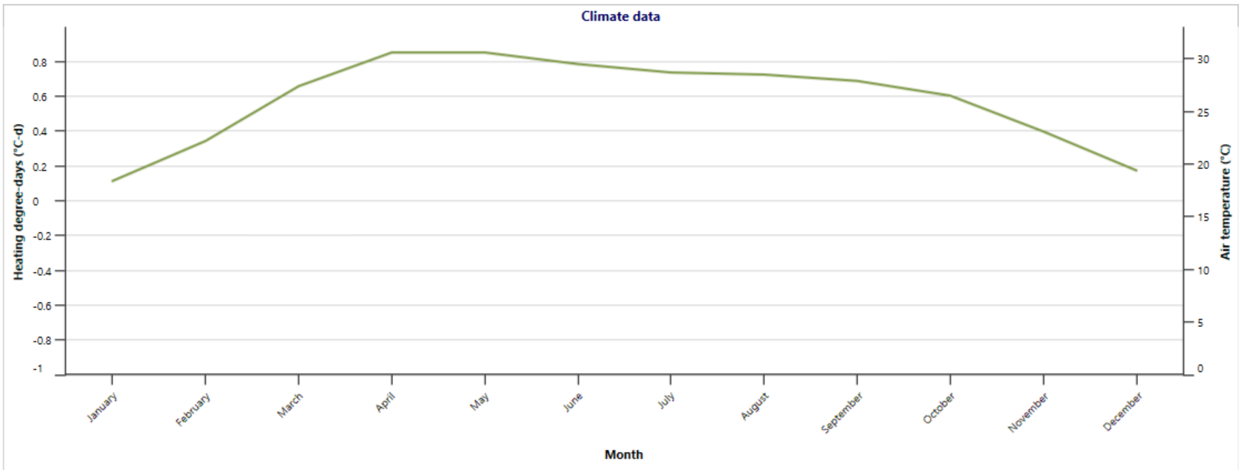


Fig 5.3 Benchmark database:

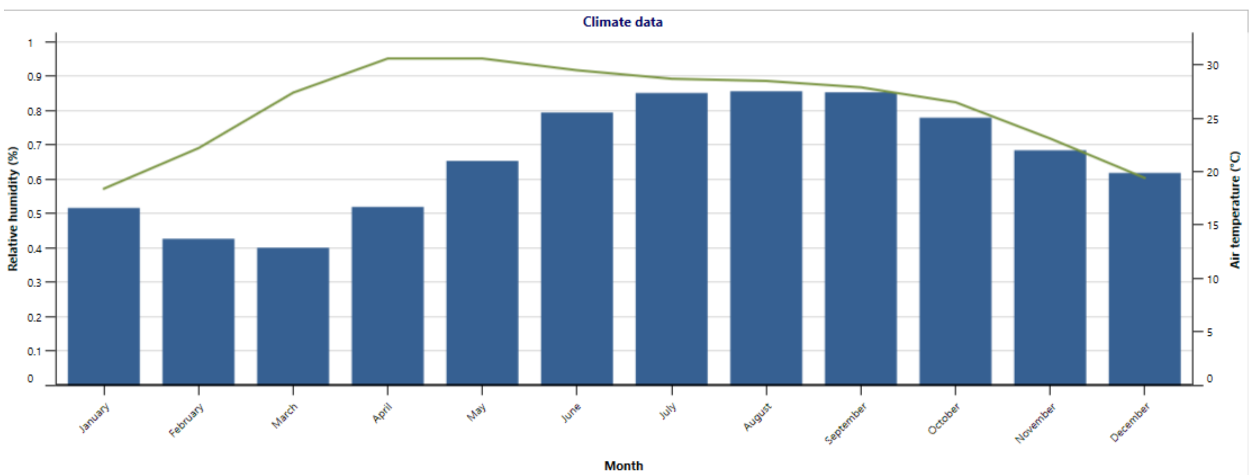
Savar, Bangladesh visibility is going to be around 9 km i.e. 5 miles and an atmospheric pressure of 1005 Mb. Atmospheric pressure, also known as barometric pressure (after the barometer), is the pressure within the atmosphere of Earth, Atmospheric pressure for East Dandabor ,Pollybuddt ,Savar ,Dhaka,



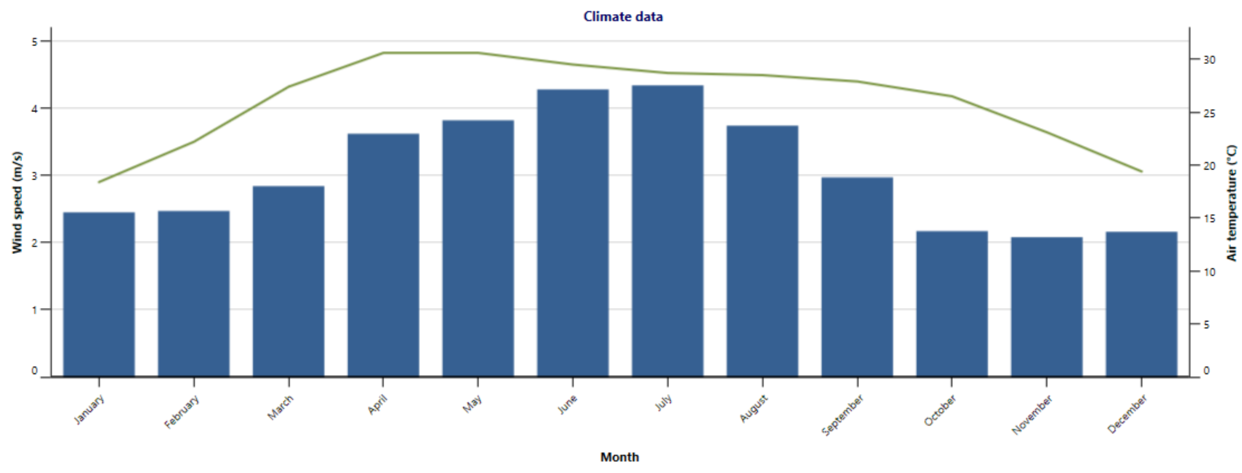
Cooling degree days for East Dandabor ,Pollybuddt ,Savar ,Dhaka



Heating degree day:



Relative humidity:



Weed speed location: East Dandabor, Pollybuddt ,Savar ,Dhaka

Wire loss, W_i :
To reduce the I^2R loss, wire size should be as large as possible and length should be short. Specific resistance of the metal is as low as possible. The cumulative loss for the wire is no more than 5%.

Wire loss, W_i :
To reduce the I^2R loss, wire size should be as large as possible and length should be short. Specific resistance of the metal is as low as possible. The cumulative loss for the wire is no more than 5%. When are slope change 20 degree

Slope :

An azimuth of 90 degrees is either a quarter of the time in the eastern direction from 0 degrees or 360 degrees. The same applies to the south 180 ° and to the west 270 °. By adding or removing 45 ° to the appropriate N, E, S or W azimuths, you may obtain azimuth corresponding to NE, SE, SW and NW. The αs is the angle of the solar azimuth and α the angle of the surface of the azimuth. If $\alpha F>180^{\circ}$, $\alpha F = \alpha F-360^{\circ}$, $\alpha F = \alpha F+360^{\circ}$, if $\alpha F<180^{\circ}$. When $\mu p<0$, $\mu p=180+\mu p$. If $\mu p>90^{\circ}$ is used for a vertical surface the Sun sets on the parallel vertical face to the opposite one.

Azimuth and Elevation are the actions taken to assess the location of an overhead satellite. Azimuth tells you how high in the sky is to look and what the elevation means. The two are in degrees calculated. It ranges between 0 ° and 360 °.

Tilt & Azimuth Angle: What angle will my solar panels need to tilt? The vertical angle of your solar panels is defined by the "tilt angle." The horizontal face in relation to the Equator is the "Azimuth angle." Solar panels should face the sun to maximize its performance.
Finally slope 40 Azimuth 20

Photovoltaic - Level 2

Resource assessment

Solar tracking mode		Fixed
Slope	°	40
Azimuth	°	20

Show data

Month	Daily solar radiation - horizontal kWh/m²/d	Daily solar radiation - tilted kWh/m²/d	Electricity export rate $/kWh	Electricity exported to grid MWh
January	1.58	2.95	0.10	2.728
February	2.53	4.08	0.10	3.355
March	3.62	4.65	0.10	4.135
April	4.46	4.73	0.10	3.960
May	5.10	4.87	0.10	4.097
June	5.61	5.13	0.10	4.080
July	5.52	5.15	0.10	4.198
August	4.91	4.98	0.10	4.065
September	3.77	4.36	0.10	3.512
October	2.38	3.25	0.10	2.803
November	1.45	2.35	0.10	2.023
December	1.28	2.47	0.10	2.249
Annual	**3.52**	**4.08**	**0.10**	**41.206**

Annual solar radiation - horizontal	MWh/m²	1.29
Annual solar radiation - tilted	MWh/m²	1.49

Photovoltaic

Type		mono-Si
Power capacity	kW	30
Manufacturer		Canadian Solar
Model		mono-Si - CS5P 200W
Number of units		120
Efficiency	%	11.8%
Nominal operating cell temperature	°C	45
Temperature coefficient	% / °C	0.4%
Solar collector area	m²	254
Miscellaneous losses	%	4%

Inverter

Efficiency	%	97%
Capacity	kW	20
Miscellaneous losses	%	0%

Summary

Capacity factor	%	15.7%
Initial costs	$/kW	2,700
	$	81,000
O&M costs (savings)	$/kW-year	
	$	
Electricity export rate		Electricity export rate - annual
	$/kWh	0.10
Electricity exported to grid	MWh	41.2
Electricity export revenue	$	4,121

Here We See 100 kw initial cost $81000

RETScreen - Cost Analysis | Subscriber: Daffodil International University - Educational Use Only

Initial costs (credits)	Unit	Quantity	Unit cost	Amount	
Initial cost				$	81,000
Show data					
User-defined	cost			$	-
Total initial costs				**$**	**81,000**

Annual costs (credits)	Unit	Quantity	Unit cost	Amount	
O&M costs (savings)	project			$	-
Show data					
User-defined	cost			$	-
Total annual costs				**$**	-

Annual savings	Unit	Quantity	Unit cost	Amount	
User-defined	cost			$	-
Total annual savings				**$**	-

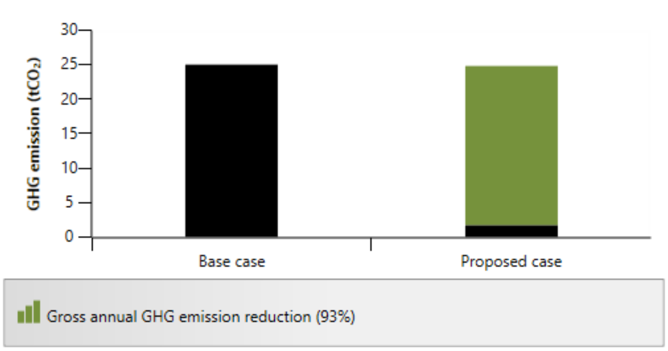
Emission analysis: Total life cycle GHG emissions from solar PV systems are similar to other renewables and nuclear energy, and much lower than coal. Harmonization increases the precision of life cycle GHG emission estimates for c-Si and TF PV, reducing variability in the interquartile range (75th minus 25th percentile value) by 65%.

RETScreen - Emission Analysis | **Subscriber: Daffodil International University - Educational Use Only**

Emission analysis

Base case electricity system (Baseline) Country - region	Fuel type	GHG emission factor (excl. T&D) $kgCO_2/kWh$	T&D losses %	GHG emission factor $kgCO_2/kWh$
Bangladesh	All types	0.564	7.0%	0.606
Electricity exported to grid	MWh	41.2	T&D losses	7.0%

GHG emission		
Base case	tCO_2	25.0
Proposed case	tCO_2	1.7
Gross annual GHG emission reduction	tCO_2	23.2



23.2 tCO_2 is equivalent to 4.3

Cars & light trucks not used

Fig 5.4 Emission analysis Bangladesh

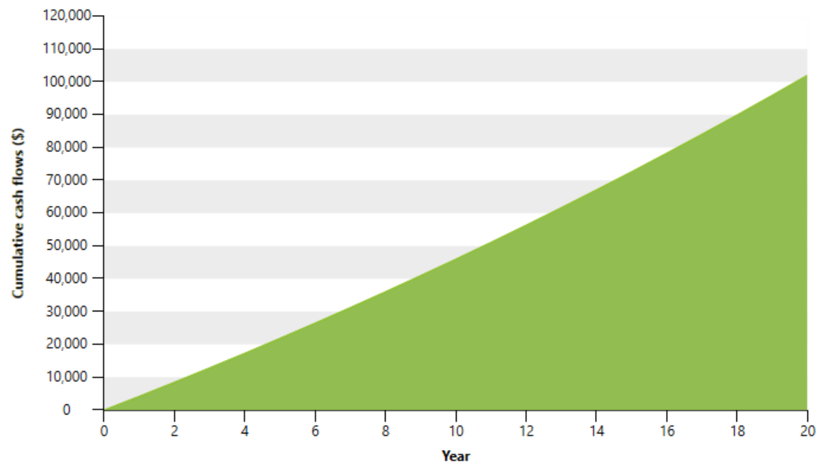
RETScreen - Financial Analysis

Subscriber: Daffodil International University - Educational Use Only

Financial analysis

Financial parameters		
Inflation rate	%	2%
Project life	yr	20
Debt ratio	%	70%
Debt interest rate	%	7%
Debt term	yr	15
Total initial costs	$	0
Incentives and grants	$	
Annual costs and debt payments		
Debt payments - 15 yrs	$	0
Total annual costs	**$**	**0**
Annual savings and revenue		
Electricity export revenue	$	4,121
GHG reduction revenue	$	0
Other revenue (cost)	$	0
CE production revenue	$	0
Total annual savings and revenue	**$**	**4,121**
Financial viability		
Pre-tax IRR - equity	%	Positive
Pre-tax IRR - assets	%	Positive
Simple payback	yr	0
Equity payback	yr	Immediate

Cumulative cash flows graph



And financial analysis

A project has a beginning and an end and passes through several phases of development known as life cycle phases.

Project life 20 years

RETScreen - Financial Analysis

Subscriber: Daffodil International University - Educational Use Only

Financial parameters

General		
Fuel cost escalation rate		2%
Inflation rate	%	2%
Discount rate	%	9%
Reinvestment rate	%	9%
Project life	yr	20
Finance		
Incentives and grants	$	
Debt ratio	%	70%
Debt	$	0
Equity	$	0
Debt interest rate	%	7%
Debt term	yr	15
Debt payments	$/yr	0
Income tax analysis		☐

Annual revenue

Electricity export revenue			
Electricity exported to grid	MWh		41
Electricity export rate	$/kWh		0.10
Electricity export revenue	$		4,121
Electricity export escalation rate	%		2%
GHG reduction revenue			
Gross GHG reduction	tCO_2/yr		23
Gross GHG reduction - 20 yrs	tCO_2		464
GHG reduction revenue	$		0
Other revenue (cost)		☐	
Clean Energy (CE) production revenue		☐	

Costs | Savings | Revenue

Initial costs		
-	$	0
Total initial costs	$	**0**
Yearly cash flows - Year 1		
Annual costs and debt payments		
Debt payments - 15 yrs	$	0
Total annual costs	**$**	**0**
Annual savings and revenue		
Electricity export revenue	$	4,121
GHG reduction revenue	$	0
Other revenue (cost)	$	0
CE production revenue	$	0
Total annual savings and revenue	**$**	**4,121**
Net yearly cash flow - Year 1	**$**	**4,121**

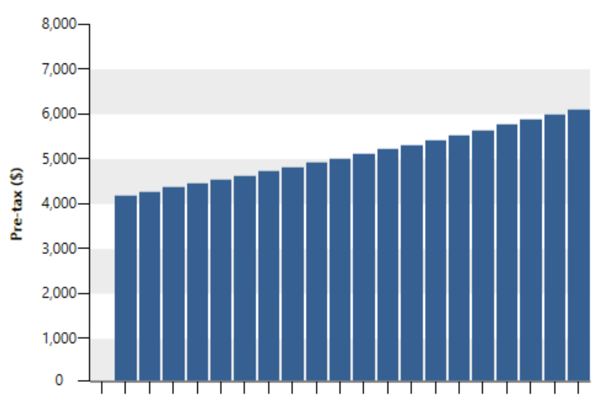
Financial viability

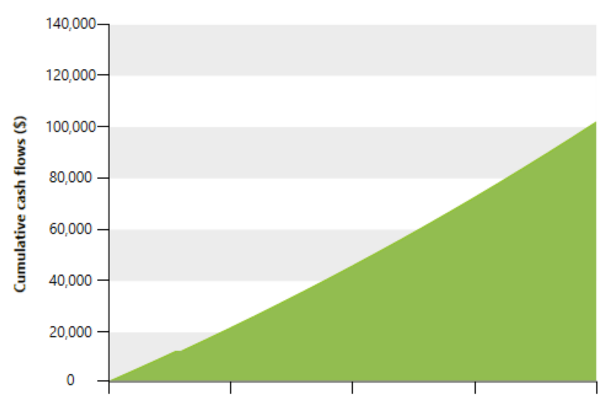
Pre-tax IRR - equity	%	Positive
Pre-tax MIRR - equity	%	Positive
Pre-tax IRR - assets	%	Positive
Pre-tax MIRR - assets	%	Positive
Simple payback	yr	0
Equity payback	yr	Immediate
Net Present Value (NPV)	$	44,123
Annual life cycle savings	$/yr	4,833
Benefit-Cost (B-C) ratio		
Debt service coverage		
GHG reduction cost	$/$tCO_2$	-208
Energy production cost	$/kWh	10,000

Yearly cash flows

Year	Pre-tax	Cumulative
#	$	$
0	0	0
1	4,203	4,203
2	4,287	8,490
3	4,373	12,863
4	4,460	17,323
5	4,549	21,872
6	4,640	26,513
7	4,733	31,246
8	4,828	36,074
9	4,924	40,998
10	5,023	46,021
11	5,123	51,145
12	5,226	56,371
13	5,330	61,701
14	5,437	67,138
15	5,546	72,684
16	5,657	78,340
17	5,770	84,110
18	5,885	89,995
19	6,003	95,998
20	6,123	102,121

Yearly cash flows





RETScreen - Financial Analysis | **Subscriber: Daffodil International University - Educational Use Only**

Financial parameters

General		
Fuel cost escalation rate		0%
Inflation rate	%	0%
Discount rate	%	0%
Reinvestment rate	%	0%
Project life	yr	35
Finance		
Incentives and grants	$	0
Debt ratio	%	0
Income tax analysis		☐

Annual revenue

Electricity export revenue		
Electricity exported to grid	MWh	41
Electricity export rate	$/kWh	0.10
Electricity export revenue	$	4,121
Electricity export escalation rate	%	0%
GHG reduction revenue		
Gross GHG reduction	tCO_2/yr	23
Gross GHG reduction - 35 yrs	tCO_2	813
GHG reduction revenue	$	0
Other revenue (cost)		☐
Clean Energy (CE) production revenue		☐

Costs | Savings | Revenue

Initial costs		
-	$	0
Total initial costs	$	**0**
Yearly cash flows - Year 1		
Annual costs and debt payments		
Debt payments	$	0
Total annual costs	$	**0**
Annual savings and revenue		
Electricity export revenue	$	4,121
GHG reduction revenue	$	0
Other revenue (cost)	$	0
CE production revenue	$	0
Total annual savings and revenue	$	**4,121**
Net yearly cash flow - Year 1	$	**4,121**

Financial viability

Pre-tax IRR - equity	%	Positive
Pre-tax MIRR - equity	%	Positive
Pre-tax IRR - assets	%	Positive
Pre-tax MIRR - assets	%	Positive
Simple payback	yr	0
Equity payback	yr	Immediate
Net Present Value (NPV)	$	144,219
Annual life cycle savings	$/yr	4,121
Benefit-Cost (B-C) ratio		
Debt service coverage		No debt
GHG reduction cost	$/tCO_2$	-177
Energy production cost	$/kWh	10,000

Yearly cash flows

Year	Pre-tax	Cumulative
#	$	$
0	0	0
1	4,121	4,121
2	4,121	8,241
3	4,121	12,362
4	4,121	16,482
5	4,121	20,603
6	4,121	24,723
7	4,121	28,844
8	4,121	32,964
9	4,121	37,085
10	4,121	41,206
11	4,121	45,326
12	4,121	49,447
13	4,121	53,567
14	4,121	57,688
15	4,121	61,808
16	4,121	65,929
17	4,121	70,049
18	4,121	74,170
19	4,121	78,290
20	4,121	82,411
21	4,121	86,532
22	4,121	90,652
23	4,121	94,773
24	4,121	98,893
25	4,121	103,014
26	4,121	107,134
27	4,121	111,255
28	4,121	115,375
29	4,121	119,496
30	4,121	123,617
31	4,121	127,737
32	4,121	131,858
33	4,121	135,978
34	4,121	140,099
35	4,121	144,219

35 years Project life

Sensitivity analysis

Perform analysis on	Net Present Value (NPV)	
Sensitivity range	25%	
Threshold	0	$

- Remove analysis — None

Electricity export rate		None
$/MWh		0.0%
75.00	-25.0%	108,164
87.50	-12.5%	126,192
100.00	0.0%	**144,219**
112.50	12.5%	162,247
125.00	25.0%	180,274

- Remove analysis — None

Electricity exported to grid		None
MWh		0.0%
30.90	-25.0%	108,164
36.05	-12.5%	126,192
41.21	0.0%	**144,219**
46.36	12.5%	162,247
51.51	25.0%	180,274

- Remove analysis — None

Electricity exported to grid		None
MWh		0.0%
30.90	-25.0%	108,164
36.05	-12.5%	126,192
41.21	0.0%	**144,219**
46.36	12.5%	162,247
51.51	25.0%	180,274

- Remove analysis — None

Electricity exported to grid		None
MWh		0.0%
30.90	-25.0%	108,164
36.05	-12.5%	126,192
41.21	0.0%	**144,219**
46.36	12.5%	162,247
51.51	25.0%	180,274

+ Add analysis

Risk analysis

Perform analysis on	Equity payback
Number of combinations	500
Random seed	No

Parameter	**Unit**	**Value**	**Range (+/-)**	**Minimum**	**Maximum**
Electricity exported to grid	MWh	41.21	25%	30.90	51.51
Electricity export rate	$/MWh	100.00	25%	75.00	125.00

Impact - Equity payback

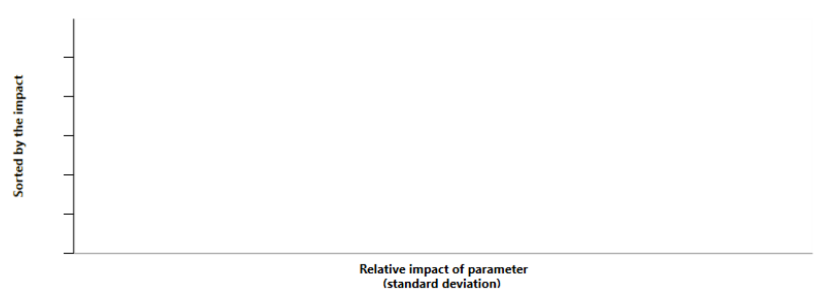


Table 5:1: Result obtained from RET Screen for 100 kw solar PV system (AC) (Off-Grid)

100 kW Stand-Alone AC system
For the 20 flat (Consider 2 fan of 80 W and 2 light of 23 W for each flat)

Project information (100KWp Off-Grid)	
Project name	100kw
Project location	BREB,East,Dandabor,Dhaka, Bangladesh
Prepared for	B.Sc.Thesis
Prepared by	MD Anisuzzaman
Project type	Power
Technology	Photovoltaic
Grid type	Off-grid
Analysis type	Method 2
Heating value reference	Lower heating value (LHV)
Climate data location	Dhaka

Load characteristics

Description	AC/DC	Intermittent resource-load correlation	Base case load(kW)	Hours of use per day(h/d)	Days of use per week (d/w)
Fan 80 W 20 Piece	DC	Negative	1.60	4.00	7
Light 23W 20 piece	DC	Negative	0.46	4.00	7

Proposed case power system		
Inverter		
Capacity	kW	20.0
Efficiency	%	97%
Miscellaneous losses	%	0%
Battery		
Days of autonomy	d	1.0
Voltage	V	48.0
Efficiency	%	90%
Maximum depth of discharge	%	60%
Charge controller efficiency	%	90%
Temperature control method		Ambient
Battery temperature	°C	45

Average battery temperature dating	%	0.5%
Capacity	Ah	320
Battery	kW h	15

Resource assessment		
Solar tracking mode		Fixed
Slope	°	40.0
Azimuth	°	20.0

Month	Daily solar radiation - horizontal	Daily Solar radiation tilted	Electrical export rate	Electricity exported to grid
	kWh/m²/d	kWh/ m²/d	$KWh	KWh
January	1.58	2.36	0.10	0.24
February	2.53	3.43	0.10	0.22
March	3.62	4.29	0.10	0.24
April	4.46	4.29	0.10	0.24
May	5.10	5.18	0.10	0.23
June	5.61	5.56	0.10	0.19
July	5.52	5.54	0.10	0.19
August	4.91	5.15	0.10	0.20
September	3.77	4.24	0.10	0.19
October	2.38	2.95	0.10	0.23
November	1.45	1.99	0.10	0.23
December	1.28	1.95	0.10	0.24
Annual	**3.52**	**3.95**	0.10	**2.65**

Annual Solar Radiation		
Annual solar radiation - horizontal	KWh/m²	1.29
Annual solar radiation - tilted	KWh/m²	1.44

Energy Model Photovoltaic		
Type		poly-Si
Power capacity	kW	20
Manufacturer	Canadian solar	
Model	Momo si CS5P 200w	
Efficiency	%	11.1%
Nominal operating cell temperature	°C	45
Temperature coefficient	% / °C	0.40%
Solar collector area	m²	169
Miscellaneous losses	%	4.00%
Summary		
Capacity factor	%	12.10%
Electricity exported to grid	MWh	26.6

Project Cost	
Initial Cost	**Amount**
Photovoltaic	$ 81000
Module Support Structure	$ 1200
Other equipment	$ 800
Storage Battery	$ 7000
Transportation	$ 400
Training & commissioning	$ 500
Inverter & Charge controller	$ 650
Contingencies	$ 266
Total Investment	**$ 91,816**
Annual costs (credits)	**Amount**
Operation & maintenance cost	$ 100
Sub-total:	$ 100
Periodic costs (credits)	**Amount**
Inverter & controller 10 yr. Battery Replacement 5 yr.	$ 650 $ 1,600

RETScreen Financial Analysis - Power project		
Financial parameters		
Fuel cost escalation rate	%	2
Inflation rate	%	2
Discount rate	%	9
Project life	yr	20
Incentives and grants	$	0
Debt ratio	%	70

GHG Reduction Savings		
Net GHG reduction	tCO_2/yr	23
Net GHG reduction - 20 yrs	tCO_2	464
Electricity Exported to grid	Mwh	41
Electricity Exported rate	$/kWh	0.10
GHG reduction credit duration	yr	20
GHG reduction credit escalation rate	%	2
Electricity Exported saving/revenue	$	4,121
Annual savings and income		
Electricity Exported saving/revenue	$	4,121
GHG reduction	$	0
Other revenue	$	0
CE production	$	0
Total annual savings and income	$	4,121

From PVsyst program Energy production cost is US $ 810/kW

Battery life

Inverter efficiency (η_i) PV module type

PV array controller Slope of the PV array Azimuth of PV array

Typical financial figures for the analysis are Energy cost escalation rate

Inflation rate Discount rate Project life [18]

The utility does not pay income tax and the system is expected to last for about 20 years or more. Feasibility study, development and engineering costs are included in PV and also balance of equipment cost which is about 10% of the total project costs. Annual operation and maintenance cost, contingency and unforeseen expenditure are considered as 7.5% of physical investment cost. [17]

Unit cost for the construction items is mostly obtained from the local market and Internet. They may not represent the actual amount at the proposed site, but there is a provision to update the unit cost. NPV and IRR and corresponding figures will be updated automatically in the model. The other factors which are considered when sizing PV panel are:

Soiling factor, S_c :

Due to the presence of dust and dirt particle in the air, the output of solar panel decreases substantially. Dust and dirt particle creates a resistance for the panel for receiving solar insolation. To overcome this problem, the panel size should be over designed by a factor, which is equivalent to 0~10%. [6]

Battery Columbic efficiency (η_c):

During the charging of Battery, gas formed inside the battery, which creates resistance for further charging the battery. To overcome this problem extra current is necessary and the panel size should be increased 5-10% for supplying this extra current.

5.3 Base of Solar Home System Design

A solar system with the following characteristics will make the most power output.
Faces South with Well Ventilation
Tilted Up At an Angle
Roof Space & Condition
No Shad

5.4 Electric load calculation

Table 5.2: Table for Load Determination of Standalone PV system for the house

Load Type	Device watt (w)	Hrs of Daily Use	No of Units	Total (W)	Total Wh
Fan	30	4	10	300	1200
Light for flat use	6	4	10	60	240
Light for Security	6	12	10	60	720
Total				420	2160

5.5 Array Sizing Worksheet

Daily E_T (Ah) requirement =Total watt-hrs per day/System nominal voltage
= 2160/24 =90 Amp
Daily load current required, Amps = E_T (Ah)/ESH
= 90/4.5
= 20Considering 20% losses,
Daily minimum array current, Amps = 1.2 × 20 = 24

Considering 175 W_p panel (Nominal Voltage 28V, Operating Current 6.5 A) Module required in series, N_S = System nominal voltage/Module nominal voltage
= 24/28 =0.85 say 1
Modules in parallel, N_P = Daily minimum array current /Module Operating current
= 24/6.5 = 3.69 say 4
Total module required = No. of module in series × No. of module in parallel
= 4 ×1=4

5.6 Controller sizing

Array short circuit current, A = Module short circuit current × Modules in Parallel
So, Controller array, Amps = 7 × 4 ×1.25 =35
Maximum DC load in Amps = DC total connected load / DC system voltage
= 420/24 = 17.5
So minimum 18 Amp rated charge controller will be needed.

5.7 Battery Sizing

The battery capacity required at C_{10} should be calculated using the following formula C_{10} (Ah) = Daily load (Ah) ×NA / (DOD × Efficiency of the battery system)
Where,
Daily amp-hrs. Requirement = E_T (Ah) =90 No of autonomy days = NA = 3
DOD (depth of discharge) = 60 %
Efficiency of the battery = 0.9
Hence, C_{10} (Ah) = (90 × 3) / (0.60 ×0.9) =500 Ah
No. of battery required in parallel = C_{10} (Ah) /Battery (Ah)
= 500/160
= 3.12 say 3 Nos.
No. of battery required in series= Nominal system voltage /cell voltage
= 24/12 = 2 Nos.
Total no. of battery required = 2 x 3 = 6 Nos.

5.8 System wire sizing

PV combiner box to controller /Controller to battery
Total amps =I_{SC} of module × Nos. of module in parallel =7 × 4 = 28 NEC required = Total amps × 1.25 × 1.25
=43.45
Wire size - 1 × 6 rm, NYY
Battery to DC distribution box / Charge controller Charging current of battery I_o Starting = 60A,

Finishing 22A Wire size - 1×16rm, NYY
MCB Selection
For DC system, MCB ratting =1.8 × maximum array current = 1.8 × 28 =50.4

Design PV system by PVSyst software

Considering roof top, tilt angle of 23° south facing, no shading effect and other condition described in article 4.1 for the requirement showing in table 4.1, PVSyst software were run and following result were found…

Operating voltage = 24V DC
Array requirement = 693 W_P say 700 W_P Using, 175 W_P Panel = 175× 4
= 700 W_P

Charge controller required = 20 Amp

Specific production	= 1567 kWh/yr
Available energy	= 1097 kWh/yr
Energy required	= 788 kWh/yr
Used energy	= 784 kWh/yr
LOLP	= 3 %
Excess unused	=224 kWh/yr
Performance ratio	= 56.4 %

5.9 Economic analysis PV system by RETScreen software

For load showing on table 5.1, autonomy days 3 and other condition mentioned in article 4.1, RETScreen was run and found Module required 700 W_P (4×175) Battery required 480 Ah with 24V

Table 5.3: To examine financial indicator following cost data were considered

Initial Cost	Amount in US $	Amount in Tk.
Photovoltaic (700Wp)	910	74620
Module Support Structure	150	12300
Other equipment	150	12300
Storage Battery	1,200	98400
Transportation	100	8200
Training & commissioning	100	8200
Chagge controller	120	9840
Contingencies	150	12300
Total Initial Investment	**2,880**	**236160**
Operation & maintenance cost per yr	20	1640
Periodic costs (credits)		
Controller replace 10 yr	120	9840
Battery Replacement 5 yr	1,000	82000

With above data RETScreen shows production cost US $ 0.51/kWh or Tk. 41.0/kWh

Financial analysis for various conditions obtained from RETScreen software

To evaluate a project or investment, it is important to calculate the NPV, IRR, payback period, year to positive cash flow and PI index for the particular project. The parameter is very sensitive to PV cost, days of autonomy, discount rate and monthly energy bill.

5.10 Effect of discount rate

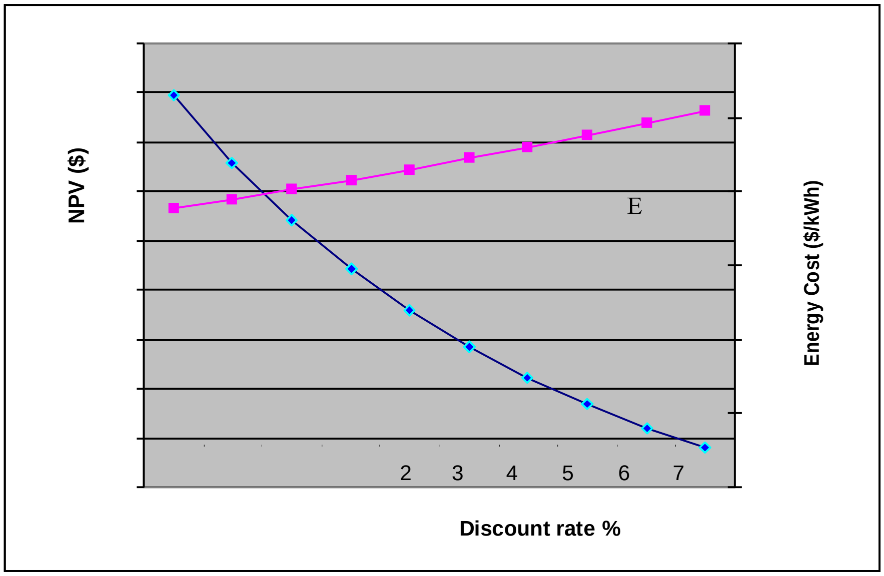


Fig. 5.5. Effect of discount on NPV and energy production cost

If considered electricity price rate Tk. 8.0 per unit in general case and 6 x 8 = Tk. 48.0 (US $ 0.6) per unit for the proposed DC system, from the Fig. 4.4 it is seen that discount rate above 8.5% is not feasible for this project at the costing point of view as above 8.5% discount rate NPV is negative.

5.11 Effect of subsidy

With no subsidy total investment for the project is $ 2880 and energy production cost is $ 0.51/kWh. If some subsidy is introduce then both the investment and energy production cost is decrease (Fig. 4.5). With no subsidy total investment is US $ 2880 and energy production cost is US $ 0.51/kWh but with 20% subsidy total investment reduced to US $ 2304 and energy production cost reduced to US $ 0.45/kWh.

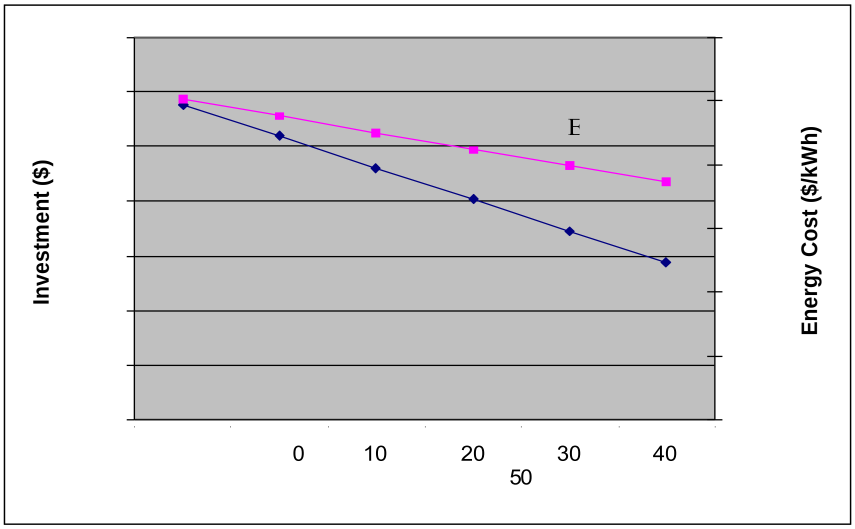


Fig. 5.6. Effect of subsidy on Investment and energy production cost

Effect of autonomy

If 2 days of autonomy (Fig. 4.6) is considered then the total investment decreases to $2380 and energy production cost is reduced to 0.48$/kWh. This result is obtained from RETScreen program. This is the actual unit energy cost of Solar Home System (SHS) used in rural electrification.

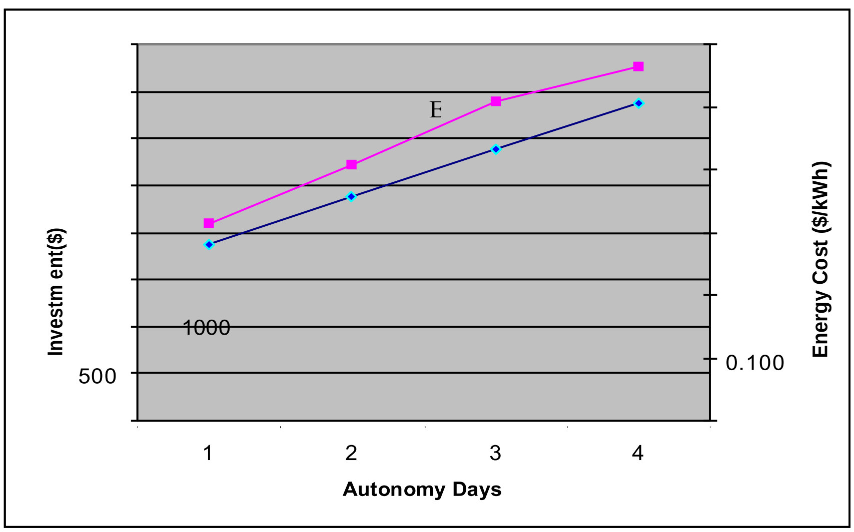


Fig. 5.7 Effect of autonomy on Investment and energy production cost

5.12 Load Comparison with general AC system

Table 5.4: Load comparison of proposed PV system with general AC system

Load Type	Daily Use(hr)	No of Units	**Proposed DC system**			**General AC system**		
			Device watt(w)	Total (W)	Total (Wh)	Device watt(w)	Total (W)	Total (Wh)
Fan	4	10	30	300	1200	100	1000	4000
Light for flat use	4	10	6	60	240	40	400	1600
Light for Security	12	10	6	60	720	60	600	7200
Total				**420**	**2160**		**2000**	**12800**

From Table 4.2 it is seen that with respect to general AC system total connected DC load is reduced to 2000/420= 4.76 say 5 times and the power consumption is reduced to 12800/2160= 5.92 say 6 times

Table 5.5 Energy consumption in a day by grid

NAME: Hazi Abu Bakkar Siddiq

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F 1, House: F1/1

Date: 1/2/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75			75	150
light reading room,32W (energy)				32	32
Tube light bed room,10W				10	10
TV,130W				130	130
Tube light bath room,10W	At le ast 30 minute s				5

Mobile charger,15W	At least 30 minutes	7.5

Total W= 334.5W

Unit Demand/consumption: (150*12) + (32*6) + (10*6) + (130* 6)+ (5*0.5)+ (7.5*0.5) = 2838.25Wh

NAME: Riziya Begum

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F1, House: F/2

Date: 9/3/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75			75	150
light reading room,18W (energy)				18	18
Tube light bed room,10W				10	10
TV,130W				130	130
Tube light bath room,10W	At least 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 320.5W

Unit Demand/consumption: (150*12) + (18*6) + (10*6) + (130* 6)+ (5*0.5)+ (7.5*0.5) =2754.25Wh

NAME: A B M Robiul Alom

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F1, House: F1/3

Date: 19/3/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W

Fan,(2) 75W	75				75*2=150
light reading room,12W (energy)					12
Tube light bed room,10W	10				20
TV,130W		120			
Tube light bath room,10W	At le ast 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 444.5W

Unit Demand/consumption: (150*6) + (12*6) + (20*6) + (250* 6)+ (5*0.5)+ (7.5*0.5) = 2598.25Wh

NAME: Md. Rowshon Akter Raju

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F 1, House: F1/4

Date: 23/3/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan,(2)75W	75*2			75	225
light reading room,32W (energy)				32	32
Tube light bed room,10W				10	10
TV,130W				130	130
Tube light bath room,10W	At least 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 409.5W

Unit Demand/consumption: (225*12) + (32*6) + (10*6) + (130* 6) + (5*0.5)+ (7.5*0.5) = 3738.25Wh

NAME: Md. Abdur Rouf

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F2, House: F2/1

Date: 27/3/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75				75
light reading room,18W (energy)				18	18
Tube light bed room,10W				10	10
TV,130W				130	130
Tube light bath room,10W	At least 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 245.5W

Unit Demand/consumption: (75*6) + (18*6) + (10*6) + (130* 6)+ (5*0.5)+ (7.5*0.5)= 1404.25Wh

NAME: Md. Rashedul Islam

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F 2, House: F2/2

Date: 02/4/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75			75	150

light reading room,32W (energy)				32	32
Tube light bed room,10W	10			10	20
TV,130W				130	130
Tube light bath room,10W	At least 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 344.5W

Unit Demand/consumption: (150*12) + (32*6) + (20*6) + (130* 6)+ (5*0.5)+ (7.5*0.5) = 2898.25Wh

NAME: Asam Pervin

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F2, House: F2/3

Date: 13/4/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75			75	150
light reading room,40W (energy)				40	40
Tube light bed room,10W				10	10
TV,130W				130	130
Tube light bath room,10W	At least 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 342.5W

Unit Demand/consumption: (150*12) + (40*6) + (10*6) + (130* 6)+ (5*0.5)+ (7.5*0.5) = 2908.78Wh

NAME: Raja

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F2, House: F2/4

Date: 14/4/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75		75	75	225
light reading room,32W (energy)	15			32	47
Tube light bed room,10W				10	10
TV,130W				130	130
Tube light bath room,10W	At least 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 424.5W

Unit Demand/consumption: (225*20) + (47*6) + (10*6) + (130* 6)+ (5*0.5)+ (7.5*0.5) = 5628.25Wh

NAME:MD Asaduzzaman

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F3, House: F3/1

Date: 6/6/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75			75	150
light reading room,32W (energy)	20			32	52
Tube light bed room,10W				20	20
TV,130W	100			130	230

Tube light bath room,10W	At least 30 minute s	5
Mobile charger,15W	At least 30 minutes	7.5

Total W= 464.5W

Unit Demand/consumption: (150*12) + (52*6) + (20*6) + (230* 6)+ (5*0.5)+ (7.5*0.5) = 3618.25Wh

NAME: Hazi A K M Yunusur Rahman

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F3, House: F3/2

Date: 17/6/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75	40		75	190
light reading room,32W (energy)	14			32	46
Tube light bed room,10W	10	5		10	25
TV,130W	70			130	200
Tube light bath room,10W	At le ast 30 minute s				10
Mobile charger,15W	At least 30 minutes				7.5

Total W= 478.5W

Unit Demand/consumption: (190*16) + (46*6) + (25*6) + (200* 6)+ (5*0.5)+ (7.5*0.5) = 4672.52Wh

NAME: Rohima

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F3, House: F3/3

Date: 18/6/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W

Fan, 75W	75	25	40	75	215
light reading room,32W (energy)				32	32
Tube light bed room,10W				10	10
TV,130W				130	130
Tube light bath room,10W	At least 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 399.5W

Unit Demand/consumption: (215*24) + (32*6) + (10*6) + (130* 6) + (5*0.5)+ (7.5*0.5 = 6198.25Wh

NAME: Abul Bashar Ahad

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F3, House: F3/4

Date: 18/6/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75			75	150
light reading room,32W (energy)				32	32
Tube light bed room,10W				10	10
TV,130W				130	130
Tube light bath room,10W	At le ast 30 minute s				5
Mobile charger,15W	At least 30 minutes				15

Total W= 342W

Unit Demand/consumption: (150*12) + (32*6) + (10*6) + (130* 6)+ (5*0.5)+ (7.5*0.5) = 2838.25Wh

NAME: MD Rakibul Islam

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F4, House: F4/1

Date: 8/7/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75			75	150
light reading room,10W (energy)	10			10	20
Tube light bed room,20W				20	20
TV,130W				130	130
Tube light bath room,10W	At le ast 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 332.5W

Unit Demand/consumption: (150*12) + (20*6) + (20*6) + (130* 6)+ (5*0.5)+ (7.5*0.5 = 2826.25Wh

NAME: REB Sub Meter

Address: East Dandabor , Pollybuddt , Savar ,Dhaka

TYPE: F4, House: F4/2

Date: 9/7/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75			75	150
light reading room,25W (energy)				25	25
Tube light bed room,20W				20	20
TV,130W				130	130

Tube light bath room,10W	At least 30 minute s	5
Mobile charger,15W	At least 30 minutes	7.5

Total W= 317.5W

Unit Demand/consumption: (150*12) + (25*6) + (20*6) + (130* 6)+ (5*0.5)+ (7.5*0.5 = 2856.25Wh

NAME:REB sub Meter

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F4, House: F4/3

Date: 19/7/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75			75	150
light reading room,32W (energy)				32	32
Fan, 75W reading room				75	75
Tube light bed room,10W				10	10
TV,130W				130	130
Tube light bath room,10W	At least 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 341.5W

Unit Demand/consumption: (150*12) + (32*6) +(75*6)+ (10*6) + (130* 6)+ (5*0.5)+ (7.5*0.5 =3288.50Wh

NAME: Nazmul Hasan

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: F4, House: F4/4

Date: 20/7/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75			75	150
light reading room,32W (energy)				32	32
Fan, 75W reading room	75			75	150
Tube light bed room,20W				20	20
TV,130W				130	130
Tube light bath room,10W	At least 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 494.5W

Unit Demand/consumption: (150*12) + (32*6)+(150*12)+ (20*6) + (130* 6)+ (5*0.5)+ (7.5*0.5 = 4698.28Wh

NAME: Munni khan

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: E1, House: E1/1

Date: 20/7/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75			75	150
light reading room,32W (energy)				32	32
Fan, 75W reading room	75			75	150

Tube light bed room,40W				40	40
TV,130W				130	130
Tube light bath room,10W	At least 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 514.5W

Unit Demand/consumption :(150 *12) + (32*6)+ (150*12)+(40*6) + (130* 6)+ (5*0.5)+ (7.5*0.5 = 4818.25Wh

NAME: Satta Siddique

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: E 1, House: E1/2

Date: 21/8/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75			75	150
light reading room,32W (energy)				32	32
TV,130W				130	130
Tube light 10 W	10			10	20
Fan, 75W reading room				75	75
Tube light bed room,10W				10	10
TV,130W				130	130
Tube light bath room,10W	At least 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 559.5W

Unit Demand/consumption: (150*12) +(32*6)+ (130*6)+(20*6) + (75*6)+(10*6)+(130* 6)+ (5*0.5)+ (7.5*0.5 = 4188.25Wh

NAME: Shafiul Alom

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: E1, House: E/3

Date: 22/7/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75			75	150
light reading room,32W (energy)				32	32
Fan, 75W reading room	75				75
Tube light bed room,40W	40			40	40
TV,130W				130	130
Tube light bath room,10W	At least 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 439.5W

Unit Demand/consumption: (150*12) +(32*6)+ (75*6) +(40*6)+ (130* 6)+ (5*0.5)+ (7.5*0.5) = 3018.25Wh

NAME: Kona

Address: East Dandabor ,Pollybuddt ,Savar ,Dhaka

TYPE: E1, House: E1/4

Date: 28/7/2020

Weather situation: fully sunny day

Consumption Time(hours)	0-6	6-10	10-18	18-24	Total W
Fan, 75W	75			75	150

light reading room,40W (energy)				40	40
light bed 10 W				10	10
Fan, 75W reading room	75			75	150
Tube light bed room,40W				40	40
TV,130W				130	130
Tube light bath room,10W	At least 30 minute s				5
Mobile charger,15W	At least 30 minutes				7.5

Total W= 532.5W

Unit Demand/consumption: (150*12) + (40*6)+(10*6)+(150*12)+ (40*6) + (130* 6)+ (5*0.5)+ (7.5*0.5) = 4926.25Wh

Total Energy consumption in a day by grid Weather situation: fully sunny day:

F1 $_{(F1+F2+F3+F4)}$ + F2 $_{(F1+F2+F3+F4)}$ +F3 $_{(F1+F2+F3+F4)}$ +F4 $_{(F1+F2+F3+F4)}$ +E1 $_{(E1+E2+E3+E4)}$ + PV system for the house (Substation)
=2838.25+2754.25+2538.25+3738.25+1404.25+2898.25+2908.78+5628.25+3618.25+4672.52+6198.25+2838.25+2826.25+2856.25+3288.5+4698.28+4818.25+4188.25+3018.25+4926.25+2160
=74816.19wh
=74.816 Kwh

Total Energy (W):

F1 $_{(F1+F2+F3+F4)}$ + F2 $_{(F1+F2+F3+F4)}$ +F3 $_{(F1+F2+F3+F4)}$ +F4 $_{(F1+F2+F3+F4)}$ +E1 $_{(E1+E2+E3+E4)}$
=334.5W+ 320.5W +444.5W +409.5W +245.5W +344.5W +342.5W +424.5W +464.5W +478.5W +399.5W +342W +332.5W +317.5W +341.5W +494.5W +514.5W +559.5W +439.5W +532.5W

=8014.5W
=8014.5/1000
=8.0145 KW

Project information (100KW Off-Grid) **= (100-8.0145) kW**
=91.9855 kW

Now if we want to sell this 91.9855 kW on the national grid then we can all sell it for a minimum of 15.5 taka BDT
Let we consider = (91.9855KW *15.5)

=**1425.77BDT**
=$16.7738USD
= (1425.77*12Month) =17109.24 TAKA BDT
= {17109.24 *(20*12 Month)} = 4106217.6 TAKA BDT 20 years
=$48308.4423 USD

CHAPTER – 6

Conclusion and Recommendation

6.1 Conclusions

This is study, PVsyst and RETScreen models used to calculate load shedding for a building containing 20 flats/apartment in urban area and to assess financial feasibility in various condition. It has seen from analysis that this type of system is variable for the different houses. Instead of using solar, flat owners can use this system as its cost is almost same as 20 nos. of solar for 20 flats. Solar is a local innovation. During load shed period it uses solar current (by inverting) to run limited load depending on solar capacity. So this is a better solution for urban area instead of using Solar.

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Here we can see that we have about 100 kilowatts from the calculation Photovoltaic energy has suffered there with $81,000 and on the other hand total cost fuel, transport, training, government insurance, inverter and etc. total cost are $ 91717,

Earlier we saw that the Economic System for Urban Area of Bangladesh Paper of Design in November 2012[23]

They was working with 2.8Kilo Watt and Homer software was used, The inverter or solar photovoltaic energy that was used there was **BP Solar Poly SI BP 12 235W**, There was a total **efficiency of 14.1%** and a total **cost of $7700[23]**

Instead we use RET screen software we work with **Canadian Solar Si CS5p 200w** where efficiency got 11.8%, **inverter Efficiency got 97 %** They used slope 30 ° and Azimuth 00°, instead we use 40° and 20°.

So we've seen that all of this means that we've gotten better in 2020 than we did in 2012, and we've come up with a set value for 20 years of cancellation.

So we can see that in our calculations we got a better result than before and got the expected result.

The load shedding is a common problem in urban areas because of the lack of electricity. But maintaining electricity supplies is important for the growth and welfare of citizens. Again population density and population growth is so high in Bangladesh, but electricity growth is very low because of the regular increase in pressure on the national grid. In the recent past, Bangladesh's government has been trying to solve this through the construction of a fast-rental solar power plant. We may therefore conclude that Bangladesh’s growing demand for energy cannot be met by traditional electricity sources and must find alternatives. In this respect, the best option for Bangladesh is renewable energy is mainly solar power. Most homeowners (who can) use solar or diesel generators in urban areas.

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The main study is the implementation of a solar panel where a grid is accessible in urban areas. But since the grid is not adequate to satisfy the electricity demand adequately, there needs to be an alternative solution to reduce pressure on the grid and help to meet the electricity demand. A SHS is a very good option because it offers renewable energy and helps to reduce environmental emissions. The demand on fossil fuel is also reduced.

6.2 Findings from the Study

The costs and efficiency of various SHS forms have been analyses in the previous chapters. It has been found from these analyzes:

(I) From here we have calculated 20 houses per month and if we activate solar panel there, how much work will we do with KW, We will be able to meet the demand of 20 houses here. And we will be able to sell for 15/20 TAKA per KW. After doing that we can see that our cost is $ 91,617 for 100 KW.

(II) After that we can see that after giving the line from 100kw to 20 houses of our project, we had a total of 91.9855kw left, which we sell at the national grid for 15.5 taka. In it we could see that the money we spent to build 100kw, after 20 years, we would get $48306.4423 from the nation grid, and connecting every house was our profit.

(III) Stand-alone PV system is ideally suited for the small and medium-sized families in urban areas, with the worst performance and cost.

(IV) Grid-interactive system is better suited for the middle or high class urban families, with the best output between the three systems. The installation of this type of device leads to a relaxed existence, as they are not faced by the burden of cargo shedding.

(V). Grid-tied is the most cost-effective system in PV systems because system losses are not found because of unused.

6.3 Recommendation

In complementary to grid electricity, the following broad recommendations have been made to speed up the growth of PV technology in urban areas:

(I) Be careful for the commercial / office consumer grid-connected PV system. As grid-connected setups can use all generated PV energy and a storage device is not mandatory, unit energy costs are less than other systems.
(II) In order to provide creative PV initiatives and at the same time prevent conventional fuel base power plants government support and incentives must be provided to private and nongovernmental organizations.

(III) Government can develop a Renewable Energy Fund to mobilize capital in this sector for Private and NGOs.

Will obtain funds at fair renewable energy expansion rates.

6.4 References

1.https://en.wikipedia.org/wiki/List_of_countries_by_electricity_consumption
2.https://www.nationalgeographic.org/encyclopedia/hydroelectric-energy/#:~:text=Hydroelectric%20energy%2C%20also%20called%20hydroelectric,used%20this%20force%20for%20millennia.
3.https://www.enago.com/academy/what-is-background-in-a-research-paper/#:~:text=The%20background%20of%20your%20study%20will%20provide%20context%20to%20the,both%20important%20and%20relevant%20studies.&text=In%20addition%2C%20the%20background%20of,%2C%20rationale%2C%20and%20research%20questions.
4.
http://bbs.portal.gov.bd/sites/default/files/files/bbs.portal.gov.bd/page/a1d32f13_8553_44f1_92e6_8ff80a4ff82e/Bangladesh%20%20Statistics-2018.pdf
&
http://www.fao.org/3/y5055e/y5055e09.htm
5. https://en.wikipedia.org/wiki/Electricity_sector_in_Bangladesh
&
https://usea.org/sites/default/files/event-file/493/overviewofbpdb.pdf
6. https://usea.org/sites/default/files/event-file/493/overviewofbpdb.pdf
7.https://www.ijser.org/paper/An-Overview-of-Rural-Electrification-in-Bangladesh.html#:~:text=The%20Bangladesh%20Rural%20Electrification%20(RE,was%20responsible%20for%20electrifying%20Bangladesh.
8.
https://www.researchgate.net/publication/308199877_The_Roles_for_Agricultural_Research_Systems_Advisory_Services_and_Capacity_Development_and_Knowledge_Transfer
9. https://www.adb.org/sites/default/files/linked-documents/49423-005-sd-01.pdf

10. http://sreda.gov.bd/d3pbs_uploads/files/policy_1_rep_english.pdf
11. https://www.paradisesolarenergy.com/blog/designing-an-attractive-looking-solar-system
12. https://www.hindawi.com/journals/isrn/2012/401761/
13. (_https://en.wikipedia.org/wiki/Solar_power_by_country)
14.https://www.researchgate.net/publication/284227299_Analysis_of_Rooftop_Solar_PV_System_Implementation_Barrier_in_Puducherry_Smart_Grid_Pilot_Project
15. https://aip.scitation.org/doi/full/10.1063/1.4812993
87
16.https://www.ijser.org/researchpaper/Present-Status-of-Installed-Solar-Energy-for-Generation-of-Electricity-in-Bangladesh.pdf
17. https://www.daily-sun.com/post/456358/Government-plans-to-install-floating-solar-panels

18.
https://www.researchgate.net/publication/245514122_ASSUMPTIONS_IN_DESIGN_AND_IN_DESIGN_RATIONALE

19. In Proceedings of the IEEE International Symposium on Power Electronics, Electrical Drives, Automation and Motion.

20. https://www.ieee.org/

21. file:///D:/Thesis/Copy/MSc%20Thesis_AM.pdf

22. https://en.wikipedia.org/wiki/List_of_countries_by_electricity_consumption

23. file:///D:/Thesis/My%20Files/Full%20Thesis.pdf