GRID-CONNECTED ROOFTOP SOLAR PV SYSTEM IN THE BANGLADESH RESIDENTIAL AREA OF GOVERNMENT PRIMARY SCHOOL

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

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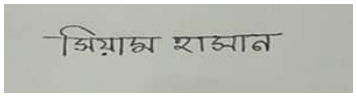

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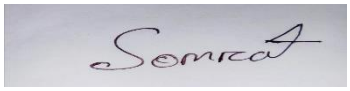

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Dedicated to

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CONTENTS

Page

List of Figure. Viii

List of Tables. ..... Viii-ix

List of charts. ix

List of Abbreviations with units and symbols. ..... ix-x

Currency and Conversion Rate. x

Acknowledgment. xi

Abstract. xi

Chapter 1: INTRODUCTION page 1-5

1.1	Background	1-3
1.2	Significance of the study	4
1.3	Objective	4
1.4	Scope	5
1.5	Research Methodology	5

Chapter 2: BACGROUND OF THE STUDY page 6-14

2.1	Country Background	6-8
2.2	Situation of Energy Resource in Bangladesh	8-9
2.3	Power Department of Bangladesh	9-11
2.4	Power generation and consumption present situation in Bangladesh.	11-14

Chapter 3: SOLAR PHOTOVOLTAIC (PV) SYSTEM. Page 15-21

3.1	Introduction	15
3.1.1	Types of solar systems	15
3.1.1.a	On-grid solar system	15
3.1.1.b	Off-grid solar system	15
3.2	Overview of renewable energy and solar power in our country	17-18
3.3	Overview of Net metering system	18-20
3.4	Solar system in government primary school of Bangladesh	20
3.4.1	Introduction	20-21
3.4.2	Scope and possibility of solar system in rooftop of primary School	21
3.5	Summery of this chapter three.	21

CHAPTER 4: DESIGN AND CALCULATION WITH RESULT OF ON-GRID SOLAR SYSTEM IN PRIMARY SCHOOL`S ROOFTOP. Page 22-32

4.1: Circuit design and formula of solar system 22-25
4.2: Total calculation and measurement of roofs space and solar system. 25
4.2.1: introduction. 25
4.2.2: Calculation of total solar panel and roofs space 26
4.2.3: Total load calculation of a government primary school third floor prominent building. 26-27
4.2.4 Total Approximate cost calculation of tis on-grid solar system. 28-29
4.3: Simulation and result of PV syst software. 30
4.3.1: Introduction: 30-32
4.4: Summery of this chapter four. 32

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS. Page 33-34

5.1: Conclusion. 33
5.2: Findings from the Study. 33
5.3: Recommendations. 34

RERRERENCES page 35-36

APPENDIX page 37-41

LIST OF FIGURES

Figure #	Figure Caption	Page #
1.1:	Globally Position of Bangladesh in the World.	2
1.2:	List of countries name by electricity production in GWh and rank.	3
2.1:	Map of Bangladesh	7
2.3:	Power Sector Management Structure of Bangladesh.	11
2.4:	Electricity Production of Bangladesh in December 2008-December 2019	14
3.1:	Grid connected PV solar system or on-grid solar system.	16
3.2:	Off-grid solar system.	16
4.1:	Equivalent circuit and symbol of a (PV) solar cell.	22
4.2.1:	Visited image of rooftop on government primary school.	25
4.2.3:	Visited image of a one room load demand of government primary school	27
4.3.1.a:	Main Result by PV syst software.	30
4.3.1.b:	All of loss diagram from PV syst software.	31
4.3.1.c:	CO2 Emission Balance. From PV syst.	31
4.3.1.d:	Normalized productions (per installed kWp) and nominal power 9.9kWp.	32

LIST OF TABLES

Table #	Tables Caption	Page #
1.1:	Continent-Wide share of population with access to electricity	2
2.2:	Energy Calculation of 2017-2018 (MTOE)	9
2.3:	power department of Bangladesh at a glance achievements of last 11 years 2019-2009	10
2.4:	In Bangladesh present installed generation capacity (MW) on 30 June 2018, 30 June 2019 & 30 June 2020.	13
2.5:	difference of electricity production of Bangladesh in 1994 to 2018 and 2019.	14
3.2:	Installed capacity of renewable energy at present in MW.	17

3.3 Net Metering Progress. 19

4.2.3: Table of total load calculation in watts. 27

4.2.4: Table of KWh calculation power consumption per day of Govt. primary school for third floor prominent building for summer season. 28

4.2.4.a: Table of KWh calculation power consumption per day of Govt. primary school for third floor prominent building for fall season. 28

4.2.4.b: Table of KWh calculation power consumption per day of Govt. primary school for third floor prominent building for spring season. 29

4.2.4.c: Table of approximate calculation in KWh power consumption of Govt. primary school for third floor prominent building for one year. 29

LIST OF CHARTS

Chart #	Chart Caption	Page #
2.4:	Consumption power pattern in 2018-2019 & Area wise electricity demand in our country.	12
3.2:	At present situation chart of installed renewable energy capacity in MW.	18
3.3:	Installed Net Metering Systems in (MW) at present in Bangladesh.	20

ABBREVIATIONS WITH UNITS AND SYMBOLS

GDP = Gross Domestic Product.

USD = United States Dollar.

GWH = Giga Watt Hour.

Km = Kilo Meter.

LPG = Liquefied Petroleum Gas.

LNG = Liquefied Natural Gas.

BSREA = Bangladesh Solar and Renewable Energy Association.

MTOE= Mega Tone of Oil Equivalent.

KGOE = Kilogram Oil Equivalent.

SHS = Solar Home System.

FY = Fiscal Year.

MW = Mega Watt.

BIPPA = Bangladesh Independent Power Producers Association.

PV = Photo Voltaic.

KW = Kilowatt.

KWp = Kilowatts Peak.

AC = Alternative Current.

DC = Direct Current.

CO2= Carbon Dioxide.

tCO2 = total carbon dioxide

BPDB = Bangladesh Power Development Board.

REB = Rural Electrification Board.

TK = Taka.

V = Volt.

W = Watt

Wp = Watt Peak

% = Percentage.

kWh/m^2 = Kilowatt hours/square meter.

$kWh/m^2/d$ = Kilowatt hours/square meter/day.

Currency and conversion rate

Bangladeshi Currency : Taka

1 United States Dollar (US$) : 84 Taka

(Source: https://www.worldforexrates.com/ , Printed on October 11, 2020)

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ABSTRACT

Our Bangladesh is one of the most densely populated areas in south-east Asia. One of the major problem of our agriculture dependent Bangladesh is the shortage of electricity generation. Due to the lack of electrical energy, that is why load shedding is the common issue of our country. But electrical energy is so much important for develop living standard. Renewable energy is the best way to solve the problem and increasing power generation. For this reason solar cell can be a potential initiative that can greatly reduce the power shortage in our country. This thesis book basically highlight on-grid solar system in government primary school`s rooftop. Here is all the strategic information for the implementation of a project of 9.9 KW. The simulation section we are used PV syst software and we were run the software. This planned system of ours will meet all the needs of the school and the excess electricity will go to the grid. Full energy directly will be exported to the 3-phase AC line. We just select Dhaka, Gazipur city corporation area for experiment the simulation. This is total system power is 9.9 KWp. The software show that total cost will be $7852.49 USD that means 659610 taka. PV syst results are, production from the system is about 15888 kWh/year. Normalized production is 4.40 kWh/kWp/day. Finally cost of produced energy is $0.031 USD per unit that means 2.6 taka per unit. Most important matter is payback period is approximately 7.3 years. . If the roofs of all government primary schools in Bangladesh can be converted by the on-grid solar system field, then the country will be able to meet a huge amount lack of electrical energy by sending additional electrical energy to the grid with full-fill demand for all of government primary schools. PV systems are now available for easy installation with all necessary accessories in a competitive market of Bangladesh. Day by day people going on interested to install the PV system in our country. PV system offer enormous benefits to countries with a good solar resource and could be deployed much faster than the current rate. Finally we want to say that it can will be a great solution for our country and economy system.

CHAPTER 1: INTRODUCTION

1.1 Background

“The demand for electricity is increasing day by day in our country. Bangladesh is the number of 134th country out of the 144 countries, while it comes to the quality of electricity supply’’.[1]

Electrical energy is very beneficial and useful energy from all kinds of energy sector. People can make or produce this electrical energy from various kinds of sources. We can convert this electrical energy many other different energy like (light, motion, temperature, etc.) for different uses. At present we can`t think without electrical energy in our modern life. In the power generation plant electricity is generated non-renewable and renewable will be both kinds. But fossil fuels is the main cased of increasing pollution and carbon dioxide emission for this reason, so now is the time for us to look at renewable energy. If we look at renewable energy, solar cells are the best and most appropriate for environment. Among the various existing renewable sources of electricity throughout the world, solar Photovoltaic technology is one of the most rapidly growth technology. Harvesting the electrical energy from PV sources is not only clean but also creates sustainable developments. Many countries have already started to collect the solar energy to meet their electrical energy demand.[2]

Population of Bangladesh is 163,046,161 (2019)

GDP of Bangladesh is (current US$) 302,571,254,131.14 (2019)

GDP Per Capita of Bangladesh is (current US$) 1,855.74 (2019)

Access to Electricity of Bangladesh (% of population) is 85.16 (2020)

Energy Imports Net of Bangladesh (% of energy use) is 16.84 (2014)

Fossil Fuel Energy Consumption of Bangladesh (% of total) is 73.77 (2014)

(Source: https://energypedia.info/wiki/Bangladesh_Energy_Situation)[8]

(Source of data: World Bank http://www.worldbank.org/)[9]

Location of Bangladesh in the world shown in the Globally Position of Bangladesh in the World Map Figure 1.1

Figure 1.1: Globally Position of Bangladesh in the World.

(Image Source: https://energypedia.info/images/f/fa/Location_Bangladesh.png)[10]

Table 1.1: Continent-Wide share of population with access to electricity.

Region	Share of population with access to electricity in % (total Population)	Share of population with access to electricity in % (urban Population)	Share of population with access to electricity in % (rural Population)	Year
North America	100%	100%	100%	2018
European Union	100%	100%	100%	2018
Europe and Central Asia	100%	100%	100%	2018
Latin America and Caribbean	98.3%	99.6%	92.9%	2018
East Asia and Pacific	98.0%	99.1%	96.3%	2018
Middle East and North Africa	96.5%	99.4%	92.3%	2018
South Asia	91.6%	99.5%	87.6%	2018
Sub-Saharan Africa	47.7%	78.1%	31.5%	2018

(Source: https://en.wikipedia.org/wiki/List_of_countries_by_electrification_rate)[11]

Table 1.1 above shows the continent wide share of population with access to electricity in this table we can see that, electricity access with percentage of total population of South Asia 91% last update 2018 and Sub-Saharan Africa 47% last update is 2018.

Figure 1.2: List of countries name by electricity production in GWh and rank.

Rank	Country/region	Electricity production (GWh)	Date of information
N/A	*World total*	27,644,800	2019[1]
1	China	10,883,000	2019[1]
2	United States	5,902,000	2019[1]
3	India	2,561,100	2020[1]
4	Russia	1,110,800	2018[1]
5	Japan	1,051,600	2018[1]
6	Canada	954,400	2018[1]
7	South Korea	794,300	2018[1]
8	Brazil	688,000	2018[1]
9	Germany	648,700	2018[1]
10	France	574,200	2018[1]
11	Saudi Arabia	383,800	2018[1]
12	UK	333,900	2018[1]
13	Mexico	332,100	2018[1]
14	Iran	310,800	2018[1]
15	Turkey (see: Electricity sector in Turkey)	302,500	2018[1]
16	Italy	290,600	2018[1]
17	Spain	275,000	2018[1]
37	Venezuela	99,200	2018[1]
38	Czech Republic	88,000	2018[1]
39	Chile	80,200	2018[1]
40	Bangladesh	79,100	2018[1]
41	Colombia	77,400	2018[1]
42	Algeria	76,400	2018[1]
43	Belgium	74,600	2018[1]
44	Kuwait	74,200	2018[1]
45	Switzerland	69,800	2018[1]
46	Finland	69,600	2018[1]
47	Israel	69,600	2018[1]
48	Austria	68,200	2018[1]
49	Romania	65,200	2018[1]
50	Paraguay	63,700	2016[3]
51	Uzbekistan	62,400	2018[1]
52	Portugal	59,900	2018[1]
53	Peru	58,817	2018[4]
54	Greece	54,200	2018[1]
55	Singapore	52,900	2018[1]
56	Bulgaria	45,300	2017[5]
57	New Zealand	44,300	2018[1]

Figure 1.2: list of country by electricity production.

(Source: https://en.wikipedia.org/wiki/List_of_countries_by_electricity_production)[12]

1.2 Significance of the study

Bangladesh is at the top in the use of solar energy

Bangladesh is at the top among the countries using solar energy in the world Out of 6 million solar panels in the world, 4 million are used in Bangladesh This information has come in the 'Renewables 2017 Global Status Report' (Source: https://p.dw.com/p/2eXEJ printed on 12.06.2017)

According to the Renewables 2018 Global Status Report, there are about 4 million solar panels in Bangladesh. Besides, Bangladesh 7 is also at the forefront in the use of clean stoves and biogas. It has also created a lot of employment. Bangladesh ranks 6th in the world in the use of renewable energy. It is mainly due to micro-credit that it has been possible to build about 4 million solar panels. "Bangladesh is followed by a number of African countries. According to the Ministry of Energy and Power, currently 2.6 percent of the country's electricity comes from renewable energy, including solar energy. (Source: https://p.dw.com/p/2eXEJ printed on 12.06.2017)

Six companies in Bangladesh are now producing solar panels Besides, a lot of research is being done on solar energy As a result, the price of solar power is falling day by day, said Dipal Chandra Barua, president of the Bangladesh Solar and Renewable Energy Association (BSREA).

Since 2016, solar energy has been used in more than 6 million places around the world, benefiting 2.5 billion people. More than half of the world's solar panels are used in Bangladesh It`s number is about 40 lakh 8 (Source: https://p.dw.com/p/2eXEJ printed on 12.06.2017) [13]

1.3 Objective

Main Objective:

1. Proper use of Roofs of all government primary school.
2. To find out which is more useful, purchase electricity constantly or an on-grid solar system?

Other Objectives:

1. Reducing the pressure on purchased electricity.
2. Reduce our carbon footprint.
3. Learn about net metering
4. Benefit at least a little bit through net metering.
5. All the students may know the benefits of solar cell from their teacher.

1.4 Scopes

Solar power will be the only source of energy in the future - this is what renewable energy researchers have been saying for some time. As the supply of energy from natural sources dwindles, so does the value of solar energy. The use of solar power has become popular in Bangladesh as well as in other countries of the world. About 30,000 'solar home systems' are being installed in the country every month.

For the first time in the country, second generation solar panels (thin film solar cells) are being made. In the meantime, the scientists of Bangladesh have been able to create this cell with the latest technology. Now the work of improving its quality is going on. It is expected to become commercially viable in the next two years. This will reduce the cost of using solar power by at least 40 percent.

Scientists at the Energy Research and Development Institute of the Bangladesh Council for Scientific and Industrial Research (BCSIR) have been researching solar energy for a long time. Muhammad Shahriar Basar, the chief scientific officer of the research team, told Samakal that research on sustainable and renewable energy began in 2012. A few months ago it was possible to make the coveted 'Thin Film Solar Cell.

The first generation crystalline silicon cell is still being used most in the world including Bangladesh. However, this new cell will give much more benefits than that. Although not exposed to direct sunlight, it is capable of generating electricity even on cloudy days. (Source: https://samakal.com/technology/article/1612257904 Printed on 24 December 2016)[14]

1.5: Research Methodology

- Visited the primary school and data collection.
- Gather some information through questions and answering.
- Collect some information from various thesis paper related this topic.
- Using by PVSyst simulation software for design and simulation.
- Gather some information from internet sources and webpage site.

CHAPTER 2:

BACGROUND OF THE STUDY

2.1 Country background

People

Population: 16.17 crores (Source: Bangladesh Bureau of Statistics). [Last updated: 2nd December 2018]. Male: 8.10 crores. Women: 6.06 crores. Literacy rate: 83.8% [Last updated: 2nd December 2018]. (Source: http://bangladesh.gov.bd/)[15]

Geography

Geographic location: 26 ° 36 'north latitude to 20 8 34' north latitude and. Longitude 8 ° 01 'East to 92 ° 41' East Longitude. Area: 147,570 square km (Land: 133,910 square km, Aquatic: 10,090 square km). [Last updated: 2nd December 2018].

Borders

North India (West Bengal and Meghalaya). West India (West Bengal). East India (Tripura and Assam) and Myanmar. Bay of Bengal to the south. Boundary length: 4,248 km. (Myanmar: 193 km, India: 4,053 km.)

Sea boundary: 560 km.

Continental shelf: up to the outer boundary of the continental margin

Special Economic Zone: 200 nautical miles

Sea area: 12 nautical miles. [Last updated: 2nd December 2018].

(Source: http://bangladesh.gov.bd/)[15]

Most parts of Bangladesh are located at an altitude of only 10 meters above sea level. It is estimated that 10% of the country's area will be submerged if the sea level rises by only 1 meter.

The climate of Bangladesh is temperate. It is divided into 6 seasons based on weather and climate - summer, monsoon, autumn, fall, winter and spring. Annual rainfall is 1500-2500 mm / 80-100 inches. This level is more than 3650 mm / 150 inches on the eastern border. The average temperature in Bangladesh is 25o Celsius. Cancer has passed through Bangladesh. Equatorial effects can be seen in the weather here. Mild winters are felt from November to

March. Summer lasts from March to June. The rainy season lasts from June to October. During this time there is a lot of rainfall due to the monsoon. Natural disasters such as floods, cyclones, tornadoes, and tidal waves hit Bangladesh almost every year.

(Source: https://bn.wikipedia.org/wiki/)[16]

Figure 2.1 Map of Bangladesh

(Image Source: http://www.maps-of-the-world.net/maps/maps-of-asia/maps-of-bangladesh/large-physical-map-of-bangladesh.jpg)[17]

"If we look in our Bangladesh, then we can see that, 94% house has electricity and they are take advantages from the electricity access of our country. Per capita electricity consumption has also increased, which is about 131 percent. Information of Department of Power, in 2009 there were 16 million consumers of electricity across the country. In the last 11 years, the number of

customers has increased to 35.1 million. During this time, the government has also provided electricity to remote villages and chars outside the national transmission line. It has also increased the per capita electricity consumption. According to earlier production, the per capita electricity consumption was 220 units (kilowatts per hour). At present it has increased to 510 units". (Source: https://www.prothomalo.com/bangladesh/ Printed on 17 November 2019)[18]

"In our Bangladesh 5.5 million household have now access to electricity by the installations of solar cells that is we know from according to power department. There is no precedent in any country in the world for installing solar panels in so many families. In 2009, 98,000 families used solar power in the country."

(Source: https://www.prothomalo.com/bangladesh/ Printed on 17 November 2019)[18]

2.2 Situation of Energy Resource in Bangladesh

''Known from commercial energy resources in Bangladesh comprise internal natural gas, coal imported oil, LPG, imported LNG, imported electricity and hydro-electricity. Biomass statements for about 29% of primary energy and rest 71% is being met by commercial energy. Natural gas accounts for about 68% of the commercial energy. Import oil information say that, for the lion`s share of the rest. Per year our country imports about 6.6 million metric ton crude and re-field petroleum protects. Moreover, power is also being generated by using Solar Home System (SHS) in on-grid. And off grid areas. From Solar Home System (SHS) power generated amount of 325MW. Final consumption of total energy is estimated around 47 MTOE. Energy consumption is average increase about 6% per year. Consumption of energy per capita in Bangladesh is on average 293kgoe (Kilogram Oil Equivalent) and per capita generation of electricity is 664 kWh with an access to electricity 90%, which is lower than those of South Asia neighboring countries.''[4]

Table 2.2: Energy Calculation of 2017-2018 (MTOE)

Name of fuel	Unit	MTOE
Oil (crude + Refined + LPG) in K ton	6948	6.9
LPG	554	0.5
Natural Gas in Bcf	961	22.3
Coal (Imported) in K ton	3395	2.1
Coal (Local) in K ton	923	0.6
RE(Hydro) in MW	230	0.2
RE(Solar) in MW	350	0.3
Electricity (Imported) in MW	625	0.5
Sub-total		33.4
Biomass		13.6
TOTAL		47.0

Source: reference[4]

2.3 Power Department of Bangladesh

As per government information, the nation would now be able to create around 21,000 megawatts of power. Despite the fact that the interest is around 12 thousand megawatts. All in all, Bangladesh presently has the ability to gracefully 9,000 megawatts of power more than the interest. 92% of the populace is currently secured by power gracefully and satisfactory force- age has been guaranteed for them. The status of the entire power department of Bangladesh is shown in table 2.3 below.

(Source: https://www.bbc.com/bengali/news-47148849 printed on 6 February 2019)[19]

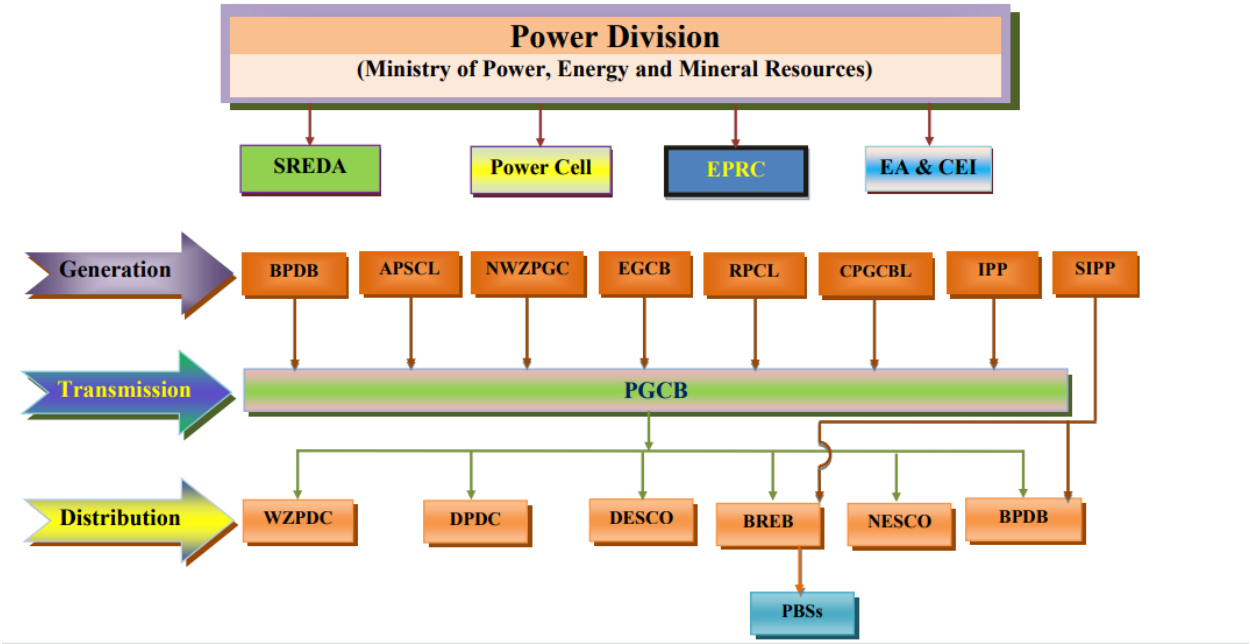
Table 2.3: power department of Bangladesh at a glance achievements of last 11 years

2019-2009

Subjects (1)	**2009 (2)**	**2019 (3)**	**Achievements of last 11 years (2019-2009) (3-2)**
Number of power stations.	27	138	(+) 111
Number of retired power plants.	--	05 (2019-20 Fiscal-Year)	--
Power generation capacity (MW).	4,942	23,548 (Including captive and renewable fuels)	(+) 18,606
Maximum power generation (MW).	3,268 (Jan 6, 2009)	12,893 (May 29, 2019)	(+) 9,625
Total transmission lines (S.KM).	8,000	12,379	(+) 4,379
Grid Substation Capacity (MVA).	15,870	47,304	(+) 31,434
Import of electricity (MW).	--	1,160	(+) 1,160
Distribution line (km).	2,60,000	5,86,000	(+) 3,26,000
Power Beneficiary Population (%).	47	98	(+) 51
Per capita power generation (KWh).	220	512 (Including captive and renewable fuels) (Fiscal Year 2019-2020)	(+) 292
Number of electricity consumers.	1 crore 8 lakhs	3 crore 84 lakhs	(+) 2 crore 76 lakhs
Irrigation connection number.	2,34,000	3,62,000	(+) 1,28,000
Annual Development Program Allocation (in-crores).	2,677	27,637 (Fiscal Year 2020-2021)	(+) 24,960
Distribution system loss (%)	14.33 (Fiscal Year 2008-2009)	8.73 (Fiscal Year 2019-2020)	(-) 5.60

(Source: https://powerdivision.gov.bd/ Last update 8 October 2020)[20]

Figure 2.3: Power Sector Management Structure of Bangladesh.

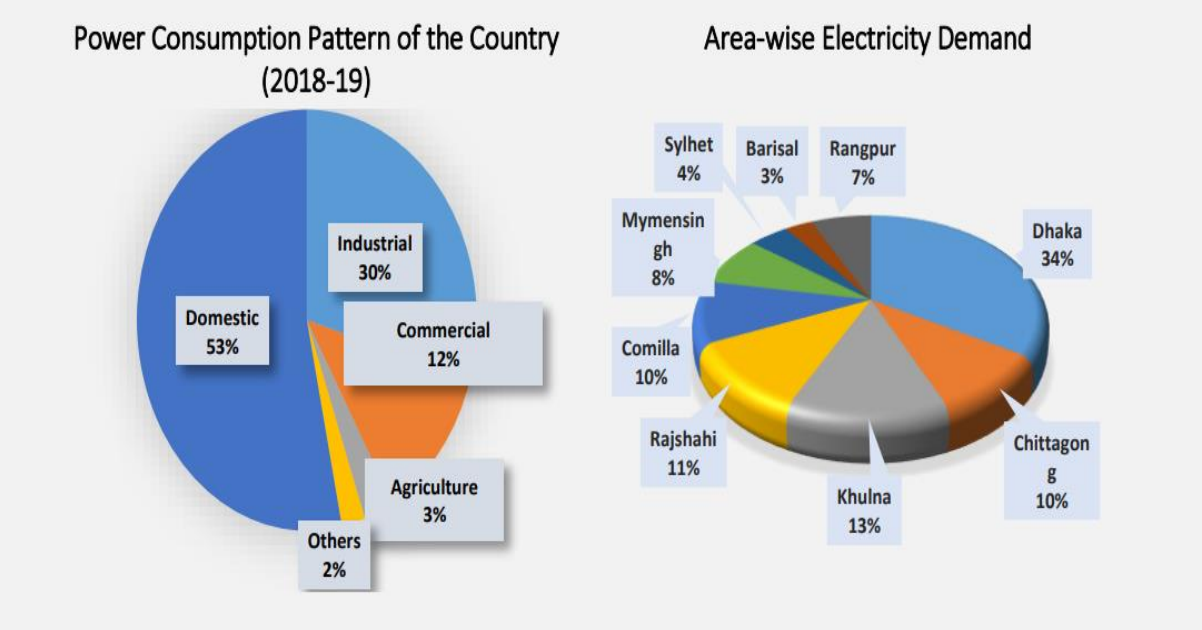


(Source:http://www.powercell.gov.bd/sites/default/files/files/powercell.portal.gov.bd/page/9976daa7_54a9_43aa_bef1_33d1f7e67524/Power%20Sector%20Organogram%20(5).pdf)

2.4 Power generation and consumption present situation in Bangladesh.

Most of the power consumption demand get from industrial area and domestic sector of our Bangladesh. Development and foundation advancement, and drug area are key development drivers inside the modern area. In FY2018-19, 53% of the nation's complete force were devoured by homegrown area while modern area burned-through 30% of the total power demand. Plus, business fragment likewise burned-through 12% of the absolute force utilization.[5]

Chart 2.4: Consumption power pattern in 2018-2019 & Area wise electricity demand in our country



Source: Reference.[5]

Despite the fact that public area represents most noteworthy power age of the nation, the commitment from private area is likewise on the ascent. Private area in Bangladesh currently represent practically 45% of the total generation. In spite of the fact that public area represents most elevated force age of the nation, the commitment from private area is additionally on the ascent driven by the administration strategy towards expanding power gracefully at the most punctual by empowering more private interest in this area. BIPPA (Bangladesh Independent Power Producers Association) pioneers in 2018 said that they have plans to contribute USD50 billion inside 2030 to keep up the private area's cooperation in power area improvement. To empower private area interest in the force area of the nation, the legislature of Bangladesh has embraced a few approaches prominently Private Sector Power Generation Policy of Bangladesh, 1996 (modified in 2004) and Policy Guideline for Enhancement of Private Participation in the Power Sector, 2008. The legislature additionally made move to modify the Electricity Act 1910, which has been renamed as Electricity Act 2016, where sufficient arrangements have been kept to encourage hidden organizations to partake in creating. The following 2.4 table shows the present installed generation capacity in (MW).[5]

Table 2.4: In Bangladesh present installed generation capacity (MW) on 30 June 2018, 30 June 2019 & 30 June 2020.

Public Sector	30 June, 2018	30 June, 2019	30 June, 2020
BPDB	5,266	5,498	5,590
APSCL	1,444	1,444	1,444
EGCB	839	839	957
NWPGCL	1,070	1,395	1395
RPCL	77	182	182
Subtotal	**8,696 (55%)**	**9,358 (49%)**	**9,568 (47%)**
Joint Venture			
B-R Power gen(JV of BPDB-RPCL)	149	149	149
BCPCL (JV of NWPGCL & CMC, China)	0	0	622
Subtotal	**149 (1%)**	**149 (1%)**	**771 (4%)**
Private Sector			
IPPS	4,452	6,503	7,233
SIPPs (BPDB)			99
SIPPs (REB)	251	251	251
15 YR. Rental	1,745	1,540	169
3/5 YR Rental			1,132
Subtotal	**6,448 (40%)**	**8,294 (44%)**	**8,884 (43%)**
Power Import			
Bheramara HVDC	660	1,000	1,000
Tripura	0	160	160
Subtotal	**660 (4%)**	**1,160 (6%)**	**1,160 (6%)**
TOTAL	**15,953**	**18,961**	**20,363**

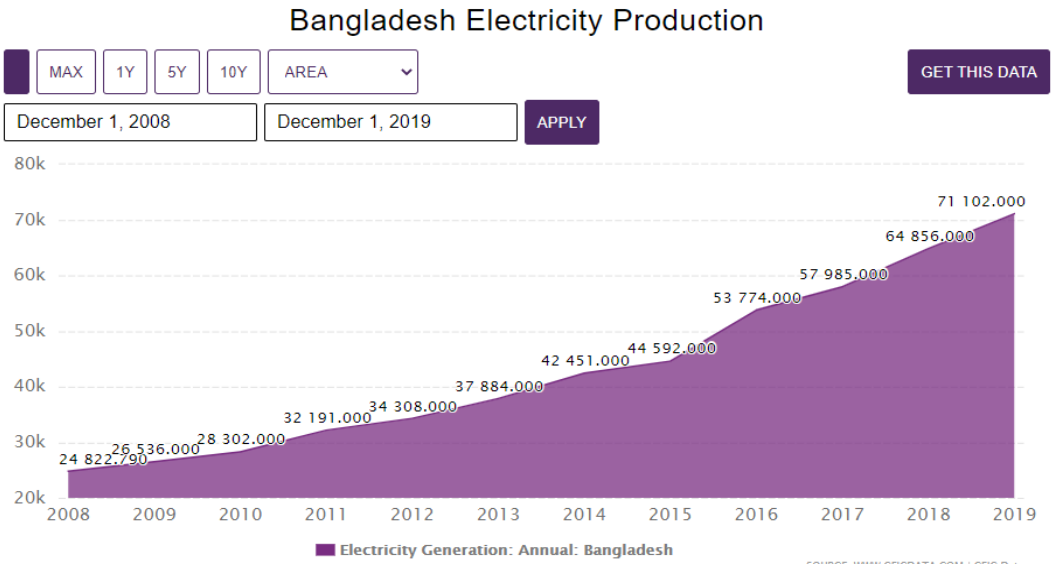
Source: Reference.[5]

In the table above, what is the current generation capacity in (MW) from different sectors such as public sector, private sector, joint venture, and imported power on 30 June 2018, on 30 June 2019, and on 30 June 2020 here we can see that, total installed generation capacity in (MW) on 30 June 2018 was 15,953 (MW), on 30 June 2019 total generation capacity in Bangladesh was 18,961 (MW) and Finally we can see that on 30 June 2020 total generation capacity is 20,363 (MW).

Power Production in Bangladesh arrived at 71,102 GWh in Dec 2019, contrasted and 64,856 GWh in the earlier year. Power Production information of Bangladesh is refreshed yearly averaging at 23,042 GWh from Dec 1994 to Dec 2019. The information arrived at a record-breaking high of 71,102 GWh in Dec 2019 and a record low of 9,541 GWh in Dec 1994. CEIC computes yearly Electricity Generation from month to month Electricity Generation. The Bangladesh Bureau of Statistics gives Electricity Generation. Net Electricity Generation is utilized.

(Source: https://www.ceicdata.com/en)[21]

Figure: 2.4: Electricity Production of Bangladesh in December 2008-December 2019



(Source: https://www.ceicdata.com/datapage/charts/ipc_bangladesh_electricity-production/?type=area&from=2008-12-01&to=2019-12-01&lang=en)

The figure: 2.5 above shows the amount of electricity generated in Bangladesh and shows the amount of electricity generated from December 2008 to December 2019. Now the table 2.4 below mentions the dramatic changes in the power generation of Bangladesh from 1994 to 2019.

Table 2.5: difference of electricity production of Bangladesh in 1994 to 2018 and 2019.

Last 2019	Previous 2018	Min 1994	Max 2019	Unit	Frequency	Range
71,102	64,856	9,541	71,102	GWh	Yearly	1994-2019

(Source: https://www.ceicdata.com/en Final updated on 25 march 2020)[21]

CHAPTER 3: SOLAR PHOTOVOLTAIC (PV) SYSTEM.

3.1: Introduction

Photoelectric cells are comprised of semiconductor substances. At present a semiconductor called silicon is utilized more. Fundamentally, when light falls on these cells, a specific bit of this light is consumed by the semiconductor. This light energy liberates the electrons from the molecules and permits the electrons to move uninhibitedly. Every one of the electromagnetic cells has at least one electric fields that power the free electrons to move a specific way. It is the progression of these electrons that makes the electric flow. This power is communicated outside by joining metal sheets above and underneath the cells. So finally easily we can say that, Solar cell is a type of equipment that is solar light energy through photovoltaic effect can convert electricity into energy.

3.1.1: Types of solar systems

The main work of a solar system is to generate electricity from sunlight. This method is usually of two types.

- On-grid solar system or grid-connected PV system.
- Off-grid solar system.

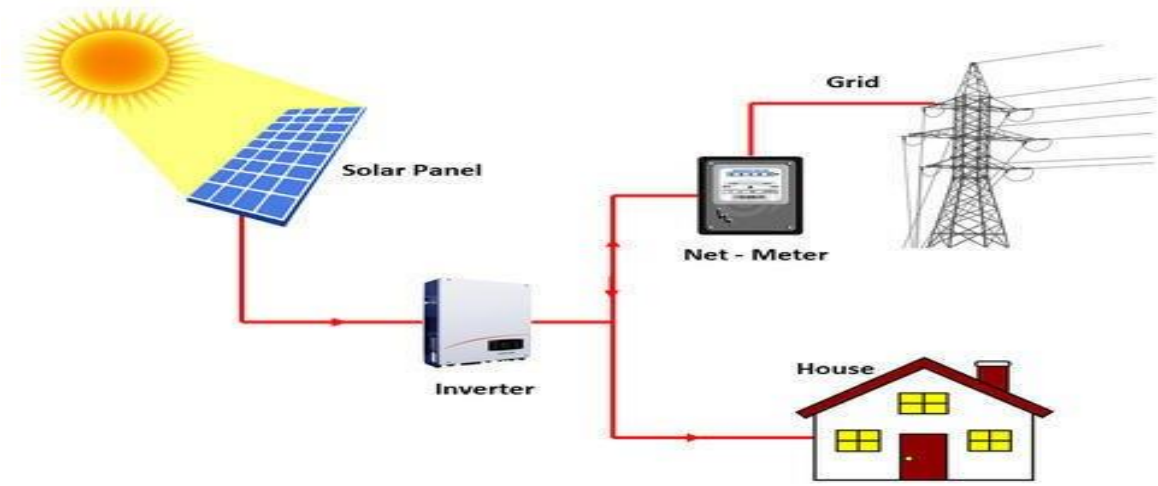
3.1.1.a: On-grid solar system

As long as there is only sunlight without batteries, the whole system is called on-grid solar system. Among the required equipment for an on-grid solar system are the notable ones solar panels, on-grid inverter and energy meter.

3.1.1.b: Off-grid solar system

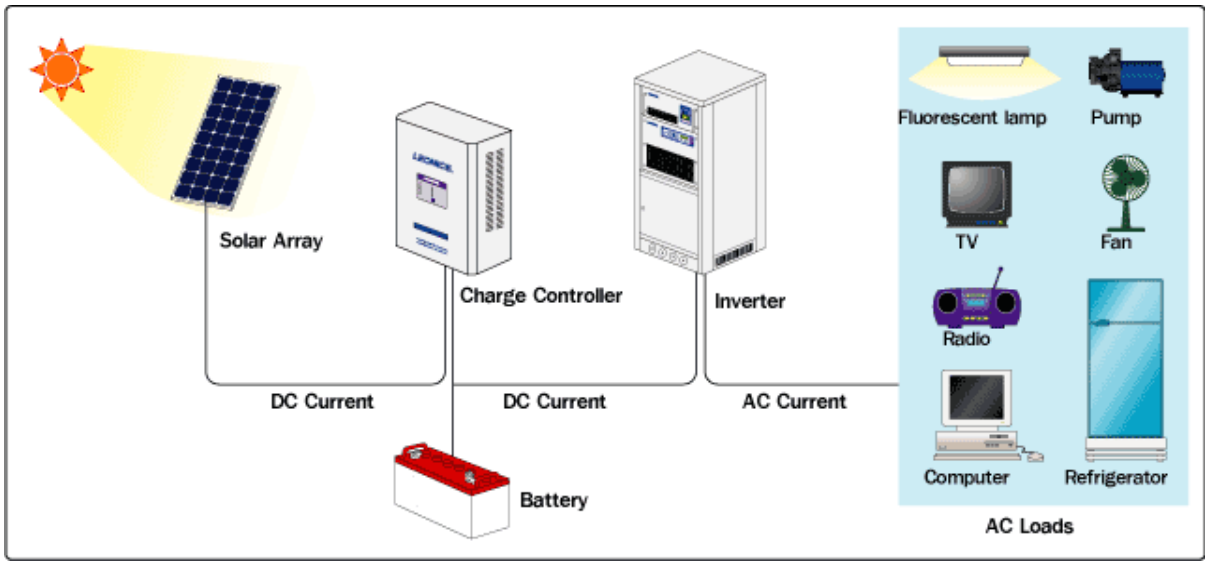
Off-grid solar system is a method of conserving solar power through the batteries and using it at night or during load shedding. Off-grid solar systems are among the equipment used is solar panels, a charge controller, an inverter and battery bank.

Figure 3.1: Grid connected PV solar system or on-grid solar system.



(Image Source: https://5.imimg.com/data5/LR/AO/JP/SELLER-89519488/on-grid-solar-system-500x500.jpg)

Figure: 3.2: Off-grid solar system.



(Image Source: http://prashantkarhade.com/wp-content/uploads/Picture14.png)

3.2 Overview of renewable energy and solar power in our country

Renewable energy is one kind of energy that is nature's constant, its source is inexhaustible. No gas is emitted as its product. Main production of renewable energy are water, tides, wind, solar, underground heat, biogas, etc. These sources are environmentally friendly, despite their high installation costs, they have no cost other than maintenance costs. Because they are have not to buy any fuel, they are in nature automatically. One of the goals of renewable energy is to provide electricity to rural areas and reduce dependence on diesel, which will reduce carbon emissions and government subsidies. One of the goals of renewable energy is to provide electricity to rural areas and reduce dependence on diesel, which will reduce carbon emissions and government subsidies. Previous few years results say that, the depletion of fossil fuels and their increasing costs have intensified the proliferation of renewable energy, which is one of the ways to ensure energy security and reduce carbon dioxide emissions. Sun powered energy is presently the most encouraging of the different sustainable power sources and has restricted utilization of biogas and biomass. Bangladesh gets a normal of 4.5 kilowatt hours/square meter of sun powered radiation every day.

Table 3.2: Installed capacity of renewable energy at present in MW.

Technology	On-grid (MW)	Off-grid (MW)	Total (MW)
Solar	138.91	328	466.91
Wind	0.9	2	2.9
Hydro	230	0	230
Biogas to Electricity	0	0.63	0.63
Biomass to Electricity	0	0.4	0.4
Total	**369.81**	**331.03**	**700.84**

(Source: http://www.sreda.gov.bd/ Final update: 2021-01-05)[22]

Above the table shown that, at present installed capacity of renewable energy situation of our country. Here we can see that, On-grid solar energy capacity 138.91 MW and Off-grid solar energy capacity is 328 MW. Total capacity by the solar technology 466.91 MW in our country. Finally we can also see that, Total renewable technology`s installed capacity is 700.84 MW.

Chart: 3.2: At present situation chart of installed renewable energy capacity in MW.

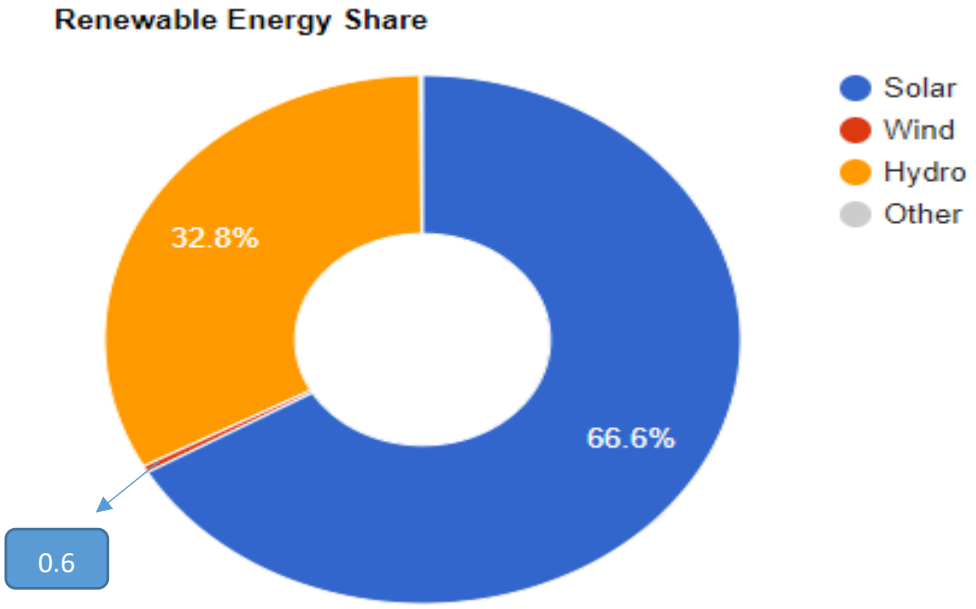


Chart of installed renewable energy capacity in MW. (Source: http://www.sreda.gov.bd/ Final update: 2021-01-05)[22]

3.3 Overview of Net metering system

The term two-way metering refers to the fact that two meters can measure the flow of electricity. Directions it measures how much energy comes from your electrical company - "KWH delivery." This too Measures the difference between generator production and customer load demand - "KWH The meter obtained does not measure the power output of our generator. The generator can do a counterbalance utilization of electrical energy of the client with any extra power production. As generator framework fabricating power, kilowatt-hours are first used to meet the client's electrical necessities, for example, lighting Furthermore, hardware. Abundance if more electrical energy is produced from the framework than the client needs kilowatt-hours are estimated, taken care of into the utility's electrical framework and utilized by different clients. When the monthly electricity bill is calculated, if the customer uses more electricity than is generated the customer only pays for net kilowatt-hours (kWh). If the customer produces more electrical energy than that the utility is used from the electrical system, then the customer receives a KWH credit, which is applied in the future. The bill also requires the customer to pay any customer charges and minimum applicable under it rate schedule.[6]

Net metering is a utility charging component accessible in many states that offers a sound representative for private and business clients who are making abundance power with their sunlight based board frameworks and sending it back to the grid. When you may have a rooftop photo voltaic system, it may well frequently generate extra electrical energy than you consume at the same time daylight hours. With net metering, the house owner is simply billed for the "net" power used every month, that is, the distinction between the vitality produced by the solar energy entity and the vitality consumed by the home over the month-to-month billing period. When your home or Enterprise is net-metered, you'll see the meter run backwards, and that means, relying upon native policies, you could get a credit score to hedge in opposition to the electrical energy you employ from the grid when it's not sunny or at nighttime. You might be then billed solely to your "net" vitality use. The surplus power generated will get put again to the grid to your neighbors to use.

Net metering can spare householders huge loads of taka on their utility installments every year, so it is a marvelous intuition to make the cash sparing other option and go photograph voltaic presently other than later. There's an extra enjoy net metering. Since your photograph voltaic plan is delivering electrical energy near the reason the spot it will probably be utilized, this lessens tension on the framework's dissemination and transmission foundation and limits power misfortune from sending voltage innumerable miles from the nearest energy plant. While some announce that net metering speaks to an out of line trouble on non-sun based electrical energy clients, different net metering money saving advantage research hold found the choice to be

Table 3.3 Net Metering Progress

Utility Name	Installed capacity	Quantity
BPDB	0.877 MW	160
BREB	7.488 MW	147
BPDC	1.331 MW	152
DESCO	1.332 MW	197
WZPDCL	0.643 MW	102
NESCO	0.638 MW	22
TOTAL	**12.309 MW**	**780**

Source: reference[7]

In the table shown that, the amount installed capacity Net Metering system, quantity and which utility how much MW power generate in our country.

Chart: 3.3: Installed Net Metering Systems in (MW) at present in Bangladesh.

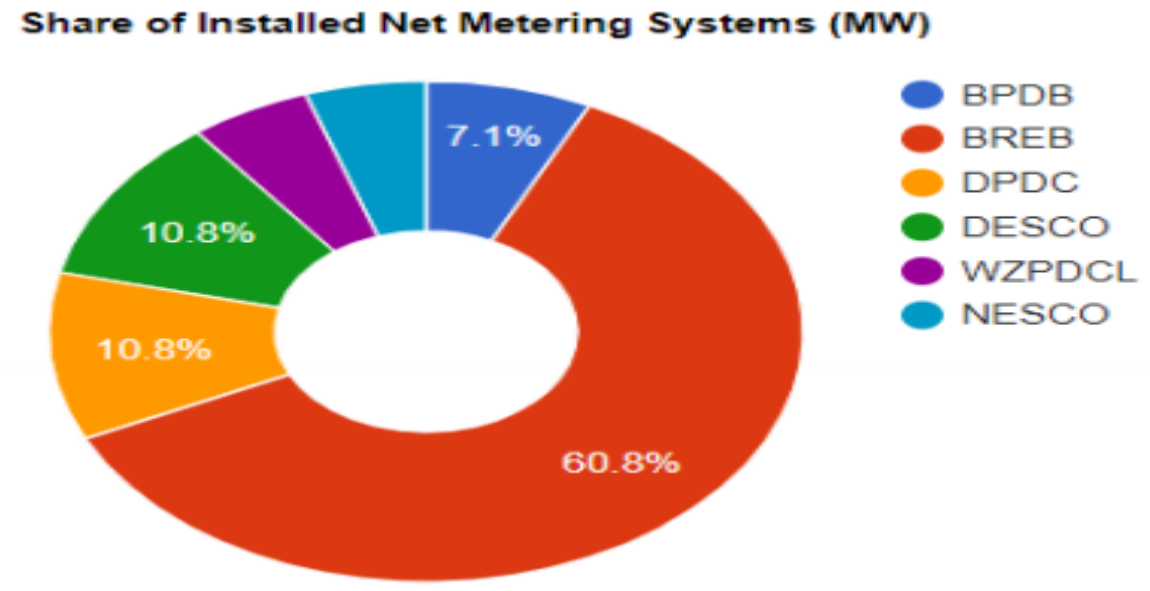


Chart of installed Net Metering System in MW at present in Bangladesh

Image source: reference[7]

In this chart shown that, how is situation of our country`s installed Net metering system in MW and which organization how much quantity power generate by Net metering system.

The Bi-directional meter estimates power streams going into and out of our home or business. The contrast between a bidirectional meter and a conventional meter is that the bidirectional meter has three unique readings: (1)delivery power, (2)how much got power, and (3)net power; while the customary meter just makes them read: (1)how much delivered.

3.4 Solar system in government primary school of Bangladesh

3.4.1 Introduction

The first step in formal education is primary education. Primary education is the main basic of all education. Primary education plays an important role in all countries of the world. Our country is no exception. Primary education also indirectly produces some far-reaching important results. As the rate of primary education increases, so does the rate of well-educated parents. The scope of primary education in Bangladesh is many wide. The

importance of this level of education is such that if quality primary education can be ensured, it is possible to bring the desired change in various sectors of the country quickly. In order to establish the country as a developed state, children need to be built with self-confidence and self-confidence. People's thinking and personality are formed in childhood. Therefore, the role of primary school is very important in shaping the personality and mentality of children.

3.4.2 Scope and possibility of solar system in rooftop of primary school

The total number of primary schools in the country is one lakh 34 thousand 147. Of these, 65,593 are government primary schools. (Source: https://www.dainikshiksha.com/ Printed on 04 march 2019)[23]. The total number of government primary schools in Bangladesh = 63,601. New government primary schools in school less areas = 634. Anew nationalized government primary school is = 25,240. Testing school = 55. (Source: http://www.dpe.gov.bd/ Last updated: 29 November 2016)[24]. The number of government primary schools in Bangladesh is so large area that, there is a he gap in the roofs of those schools, so if we want we can reduce the electric power shortage and we can sell the spare parts of production or generation of electric power by installing on grid solar systems in the collapsed areas. We can reduce a lot of pressure on the country`s demand by selling the rest of the electricity generated from our on grid solar system through the grid after it is needed.

3.5: Summery of this chapter three.

In this chapter we are try to highlight about the PV system and how to work the PV solar system with kind of PV solar system. Therefore we try to describe the main two kinds of solar system there is on-grid solar system and off-grid solar system and how to work they are. Then we are show this chapter design and we describe point 3.2: Overview of renewable energy and solar power in our country with how is situation at present in our country. Therefore we show the table 3.2: Installed capacity of renewable energy at present in MW and then point 3.3: Overview of Net metering system shown this chapter. We also try to present this chapter how is condition and net metering progress in our country at table 3.3: with chart another point. Finally we are present this chapter at point 3.4: Solar system in government primary school of Bangladesh and Scope and possibility of solar system in rooftop of primary school.

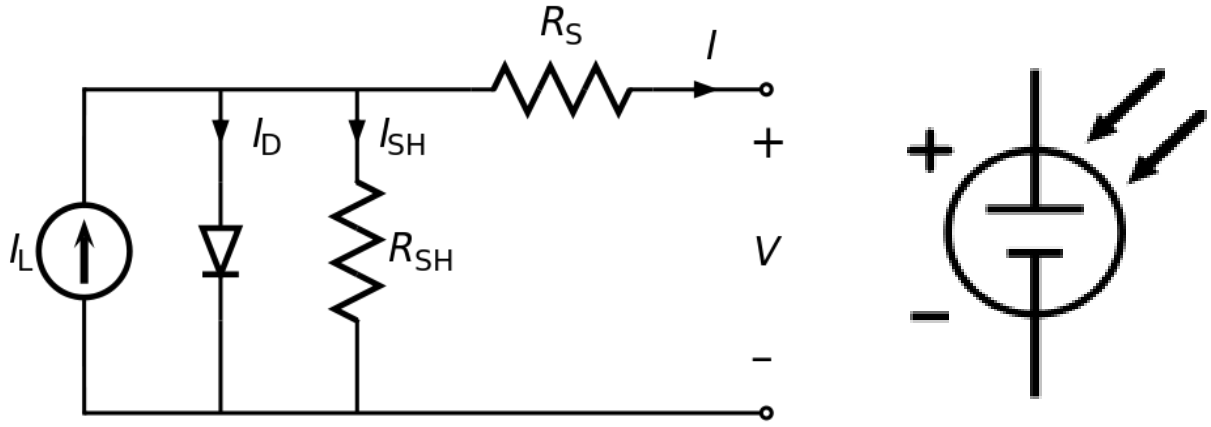
CHAPTER 4:

DESIGN AND CALCULATION WITH RESULT OF ON-GRID SOLAR SYSTEM IN PRIMARY SCHOOL`S ROOFTOP.

4.1: Circuit design and formula of solar system

To comprehend the electronic conduct of a sun powered cell, it is valuable to make a model which is electrically same, and depends on discrete electrical parts whose conduct is notable. An ideal sun powered cell might be demonstrated by a current source in corresponding with a diode; practically speaking no sunlight based cell is ideal, so a shunt obstruction and an arrangement opposition segment are added to the model. The subsequent equal circuit of a sunlight based cell is appeared on the left. Additionally appeared, on the right, is the schematic portrayal of a sun based cell for use in circuit graphs.

Figure 4.1: Equivalent circuit and symbol of a (PV) solar cell.



The Equivalent circuit and symbol of solar cell. (Image source: https://upload.wikimedia.org/)

Criteria equation:

From the identical circuit it is clear that the current delivered by the solar cell is equivalent to that created by the current source, short what courses through the diode, less that which moves through the shunt resistor

$I = I_L - I_D - I_{SH}$

Where,

- I = Output current (amperes)
- I_L = Photo generated current (amperes)
- I_D = Diode current (amperes)
- I_{SH} = Shunt current (amperes)

The current through these components is represented by the voltage across them:

$V_j = V + I_{RS}$

Where,

- V_j = voltage across both diode and resistor R_{SH} (volts)
- V = voltage across the output terminals (volts)
- I = output current (amperes)
- RS = series resistance (Ω).

By the Shockley diode equation, the current diverted through the diode is:

$$I_D = I_0 \left\{ \exp\left[\frac{qV_j}{nkT}\right] - 1 \right\}$$

Where,

- I_0 = reverse saturation current (amperes)
- n = diode ideality factor (1 for an ideal diode)
- q = elementary charge
- k = Boltzmann's constant
- T = absolute temperature
- At 25°C, kT/q \approximate 0.0259 volts.

By Ohm's law, the current diverted through the shunt resistor is:

$$I_{SH} = \frac{V_j}{R_{SH}}$$

Where, R_{SH} = shunt resistance (Ω).

Subbing these into the principal condition delivers the trademark condition of a sun oriented cell, which relates sun powered cell boundaries to the yield current and voltage:

$$I = I_L - I_0 \left\{ \exp\left[\frac{q(V + IR_S)}{nkT}\right] - 1 \right\} - \frac{V + IR_S}{R_{SH}}.$$

An elective deduction delivers a condition comparable in appearance, however with V on the left-hand side. The two options are characters; that is, they yield exactly similar outcomes. On a fundamental level, given a specific working voltage V the condition might be fathomed to decide the working current I at that voltage. Be that as it may, in light of the fact that the condition includes I on the two sides in a supernatural capacity the condition has no broad

diagnostic arrangement. Be that as it may, even without an answer it is genuinely enlightening. Besides, it is handily unraveled utilizing mathematical strategies. (An overall scientific answer for the condition is conceivable utilizing Lambert's W work, however since Lambert's W by and large itself must be unraveled mathematically this is a detail.) Since the boundaries I_0, n, R_S, and R_{SH} can't be estimated straightforwardly, the most widely recognized use of the trademark condition is nonlinear relapse to extricate the estimations of these boundaries based on their consolidated impact on sunlight based cell conduct.

Open-circuit voltage and short-circuit current:

At the point when the cell is worked at open circuit, I = 0 and the voltage over the yield terminals is characterized as the open-circuit voltage. Expecting the shunt opposition is sufficiently high to disregard the last term of the trademark condition, the open-circuit voltage V_{OC} is:

$$V_{OC} \approx \frac{kT}{q} \ln \left(\frac{I_L}{I_0} + 1 \right).$$

Also, when the cell is worked at cut off, = 0 and the current I through the terminals is characterized as the short out current. It very well may be indicated that for an excellent sunlight based cell (low RS and I0, and high RSH) the short out current ISC is:

$$I_{SC} \approx I_L.$$

Effect of physical size:

The estimations of I_0, R_S, and R_{SH} are reliant upon the actual size of the sun based cell. In contrasting in any case indistinguishable cells, a cell with double the surface zone of another will, on a fundamental level, have twofold the I_0 in light of the fact that it has double the intersection region across which current can spill. It will likewise have a large portion of the R_S and R_{SH} in light of the fact that it has double the cross-sectional region through which current can stream. Therefore, the trademark condition is much of the time written regarding current thickness, or current delivered per unit cell zone:

$$J = J_L - J_0 \left\{ \exp \left[\frac{q(V + Jr_S)}{nkT} \right] - 1 \right\} - \frac{V + Jr_S}{r_{SH}}$$

Where,

- J = current density (amperes/cm2)
- JL = photo generated current density (amperes/cm2)
- J0 = reverse saturation current density (amperes/cm2)
- r_S = specific series resistance (Ω-cm2)
- r_{SH} = specific shunt resistance (Ω-cm2).

Very small cells may exhibit higher values of J_0 or lower values of R_{SH} than larger cells that are otherwise identical. In such cases, comparisons between cells must be made cautiously and with these effects in mind.

4.2: Total calculation and measurement of roofs space and solar system.

4.2.1: introduction.

The information we received from the primary school showed that a third floor prominent building there has three rooms on each floor. Per room is 20 foot wide and 30 foot long so, each room is 600 square foot and we know there has total three rooms per floor finally we get total 1800 square foot. Then we can say that, we have total 1800 square foot roofs for make an On-grid solar system. Although we have so much space for installation huge amount or quantity generation system of solar but we can`t use the total roofs because for maintenance and installation and for proper angel, spectrum, temperature, amount of sun light these various reasons we should eliminate a huge amount of space of roofs. On-grid solar panel is available in our marketplace that, 330 watts per panel and it is 7.5 foot length and 3 foot wide so, it is 22.5 square foot per panel. These is generate 36 volt.

Figure 4.2.1: Visited image of rooftop on government primary school.

(Image Source: Author.) The image is rooftop of government primary school.

4.2.2: Calculation of total solar panel and roofs space

Total rooftop is = 1800 square foot.

On-grid solar per panel = 6.96 foot length and 3 foot wide has marketplace. So (6.96 x 3) square foot. = 20.88 square foot.

So, on-grid solar per panel = 20.88 square foot.

If we use 30 panel then it will be = 20.88 x 30 = 626.4 square foot.

Since, we use 675 square foot then, we should eliminate = (1800 – 626.4) = 1173.6 square foot.

Per panel can be generate = 330 watts and 36 volts.

Since, we just use only 30 panel then it will be = (330 x 30) = 9900 watts.

So, we just use only 675 square foot that will generate 9900 watts or 9.9 KW.

Finally Here,

Total roofs = 1800 square foot.	Eliminate roofs = 1125 square foot.
Uses need space roofs = 675 square foot.	Panel piece = 30
Per panel = 37.8 volts.	Every panel = 330 watts.
Per panel = 20.88 square foot.	Total generation ability = 9.9 KW

4.2.3: Total load calculation of a government primary school third floor prominent building.

The government primary school at present in our country is a model school. We are all know that at present government primary schools are being built all over Bangladesh according to the same structure. However in some areas, just only one floor prominent building has been completed, another areas roughly second floor prominent building has been completed and some areas, total third floor prominent building has been completed. However, the load demand of all the rooms is the same of government primary schools. If we have seen below the photo then, we can see per room has total 4 fan and 2 tube light this is used same load for all rooms without office room. The office room has extra one computer and every primary school has at present one motor for supply water for the students. Every room has 4 fan that is 56`` inch and 4 tube light that is 4` foot.

Figure 4.2.3: Visited image of a one room load demand of government primary school.

(Image Source: Author.) Load demand image of a one room for government primary school.

4.2.3: Table of total load calculation in watts.

S. L.	Purpose	Name of appliance	Number of appliance per room/corridor	Number of room/corridor	Total appliances	Watts per appliance	Total watts for demand loads
1	Class room	Ceiling Fan	4 piece (56 inch)	9 rooms	36 piece	65 watts	(36 x 65) = 2,340 watts
2	Class room	Tube Light	4 piece (4 foot)	9 rooms	36 piece	40 watts	(36 x 40) = 1,440 watts
3	Corridor	Fluorescent Light	2 piece	3 corridors	6 piece	20 watts	(6 x 20) = 120 watts
4	Office room	Desktop computer	---	---	1 piece	100 watts	(1 x 100) = 100 watts
5	Water supply	Water Pump	---	---	1 piece	746 watts 1 HP	(1 x 746) = 746 watts
6	**Total watts**	---	---	---	---	---	**4,746 watts**

We can see from the table above that, showed total load demand in watts and each other wattage according to purpose separately. From this table we have got total load demands is 4,746 watts.

4.2.4 Total Approximate cost calculation of tis on-grid solar system.

Various equipment price these have been collected by call visit, internet site visit and question answering.

Let consider here,

A-grade On-grid solar panel per watt price 55 taka = (9900 x 55) = 5,44500TK

On grid inverter price for 10 Kw = 75,000 TK

Installation cost: net meter, circuit breaker, wire, and installation cost total = 40,110 TK

Total cost = 6,59610TK

4.2.4: Table of KWh calculation power consumption per day of Govt. primary school for third floor prominent building for summer season.

Appliance	Piece	watts	Total KWh per day
Ceiling Fan	36 piece	65 watts	(2.34 x 7) = 16.38 KWh
Tube Light	36 piece	40 watts	(1.44 x 4) = 5.76 KWh
Fluorescent Light	6 piece	20 watts	(0.12 x 3) = 0.36 KWh
Desktop Computer	1 piece	100 watts	(0.1 x 8) = 0.8 KWh
Water Pump	1 piece	746 watts	(0.746 x 2) = 1.492 KWh
TOTAL	----	----	**(24.792) KWh**

From these table we can see that, per day power consumption of Govt. primary school for third floor prominent building is 24.792 KWh. We also know that, it can be more or less different seasons and different times. Since per day consumption 24.792 then it`s will be for one month in summer season (24.792 x 30) = 743.76 KWh. We know one KWh is equal to per unit. If we consider per unit electricity bill = 6.02 TK.

(Tariff rate source: http://www.reb.gov.bd/)[25]. Then electricity bill will be for one month in summer season (743.76 x 6.02) = 4,477 TK.

4.2.4.a: Table of KWh calculation power consumption per day of Govt. primary school for third floor prominent building for fall season.

Appliance	Piece	watts	Total KWh per day
Ceiling Fan	36 piece	65 watts	(2.34 x 5) = 11.7 KWh
Tube Light	36 piece	40 watts	(1.44 x 6) = 8.64 KWh
Fluorescent Light	6 piece	20 watts	(0.12 x 3) = 0.36 KWh
Desktop Computer	1 piece	100 watts	(0.1 x 8) = 0.8 KWh
Water Pump	1 piece	746 watts	(0.746 x 2) = 1.492 KWh
TOTAL	----	----	**(22.992) KWh**

Since per day consumption 22.992KWh in fall season then it`s will be for one month (22.992 x 30) = 690KWh. We know one KWh is equal to per unit. If we consider per unit electricity bill =6.02 TK. Then electricity bill will be for one month in fall season (690 x 6.02) = 4,154 TK.

4.2.4.b: Table of KWh calculation power consumption per day of Govt. primary school for third floor prominent building for spring season.

Appliance	**Piece**	**watts**	**Total KWh per day**
Ceiling Fan	36 piece	65 watts	(2.34 x 6) = 14.04 KWh
Tube Light	36 piece	40 watts	(1.44 x 4) = 5.76 KWh
Fluorescent Light	6 piece	20 watts	(0.12 x 3) = 0.36 KWh
Desktop Computer	1 piece	100 watts	(0.1 x 8) = 0.8 KWh
Water Pump	1 piece	746 watts	(0.746 x 2) = 1.492 KWh
TOTAL	**----**	**----**	**(22.454) KWh**

Since per day consumption 22.454KWh in spring season then it`s will be for one month (22.454 x 30) = 673.62KWh. We know one KWh is equal to per unit. If we consider per unit electricity bill = 6.02 TK. Then electricity bill will be for one month in fall season (673.62 x 6.02) = 4,055 TK.

We just divided the total year by the three seasons. Which is consist per season 4 months and we just find out the average per month load demand and consumption demand with how will be bill rate per month of per seasons.

4.2.4.c: Table of approximate calculation in KWh power consumption of Govt. primary school for third floor prominent building for one year.

Serial No.	**Name of months**	**(KWh x Day) per month**	**Total KWh per month**
1	January	(22.4 x 31)	694.4 KWh
2	February	(22.1 x 28)	618.8 KWh
3	March	(22.9 x 31)	709.9 KWh
4	April	(22.6 x 30)	678 KWh
5	May	(22.5 x 31)	697.5 KWh
6	June	(22.7 x 30)	681 KWh
7	July	(24.2 x 31)	750.2 KWh
8	August	(24.7 x 31)	765.7 KWh
9	September	(24.8 x 30)	744 KWh
10	October	(23.5 x 31)	728.5 KWh
11	November	(22.2 x 30)	666 KWh
12	December	(22.3 x 31)	691.3 KWh
13	**Total**		**8425.3 KWh**

From this above table express that, total one year approximate power consumption in KWh of government primary school third floor prominent building. We have seen that, total one year approximately consume 8425.3 KWh.

4.3: Simulation and result of PV syst software.

4.3.1: Introduction:

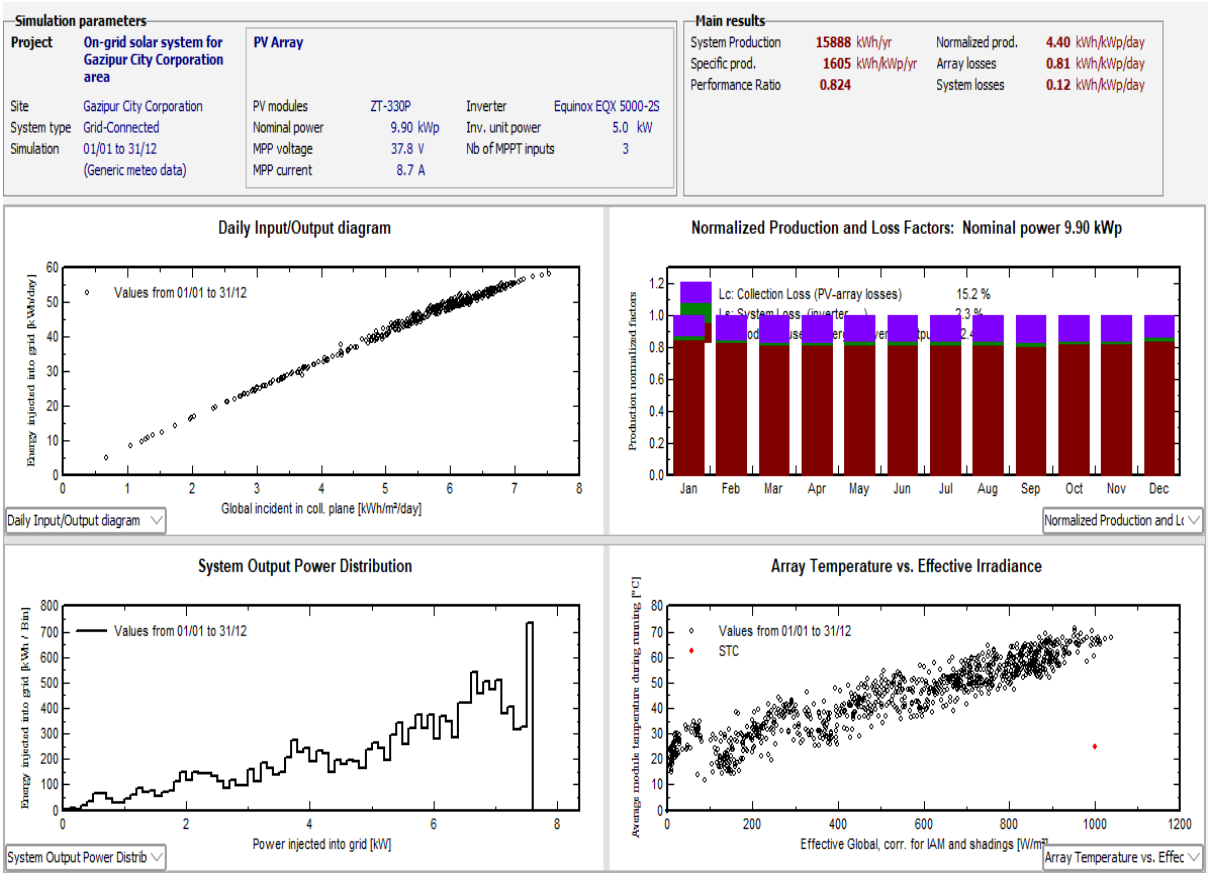
The simulation section we are used PV syst software and we were run the software. Full energy directly will be exported to the 3-phase AC line. We just select Dhaka, Gazipur city corporation area for experiment the simulation. This is total system power is 9.9 KWp. The software show that total cost will be $7852.49 USD that means 659610 taka. PV syst results are, production from the system is about 15888 kWh/year. Normalized production is 4.40 kWh/kWp/day. Finally cost of produced energy is $0.031 USD per unit that means 2.6 taka per unit. Most important matter is payback period is approximately 7.3 years.

Project summary: Geographical site is Gazipur city corporation in Bangladesh. Latitude is 24.00 *N longitude is 90.42 *E and altitude is 11 m**.**

System summary: Grid connected system and PV field orientation fixd plan and tilt/azimuth 30/0* no shading system**.**

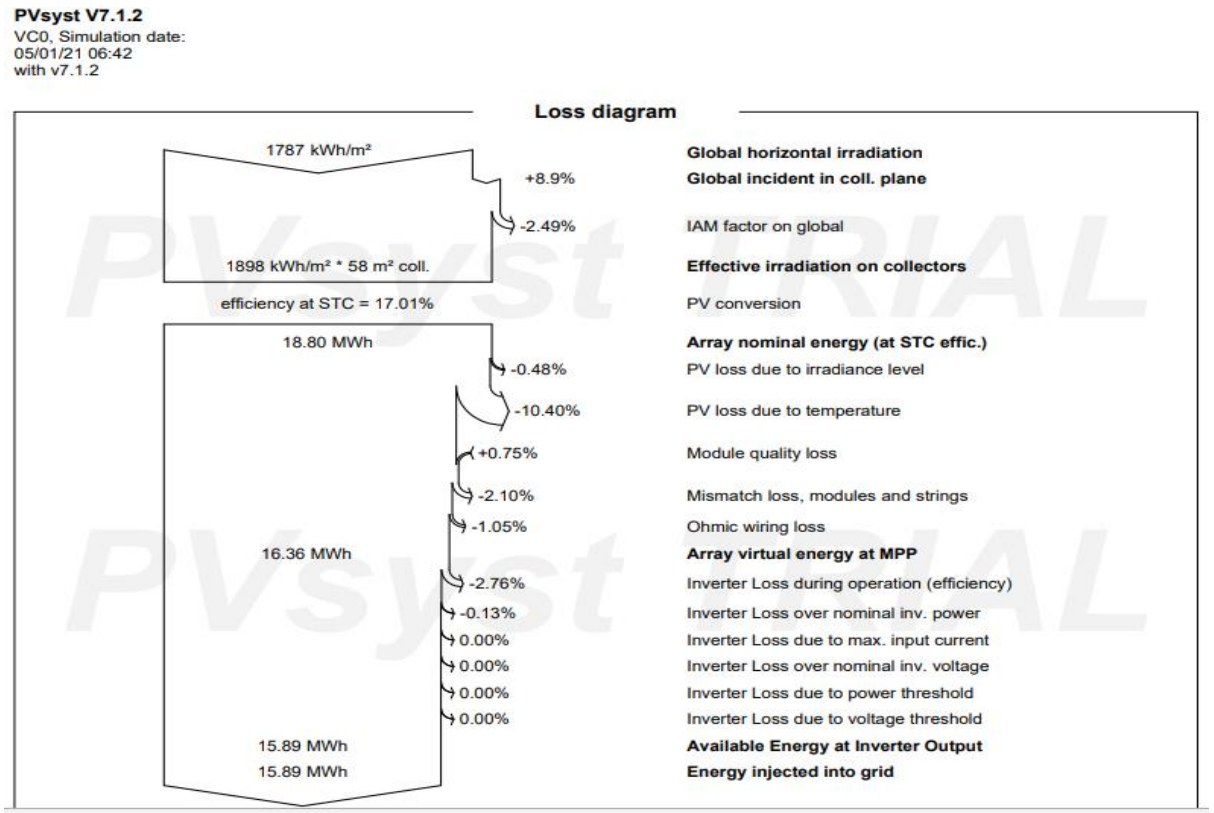
Result summary: Produced energy will be 15.89 MWh/year and specific production is 1605 kWh /kWp/year. Performance ratio (PF) 82.44%.

Figure 4.3.1.a: Main Result by PV syst software.



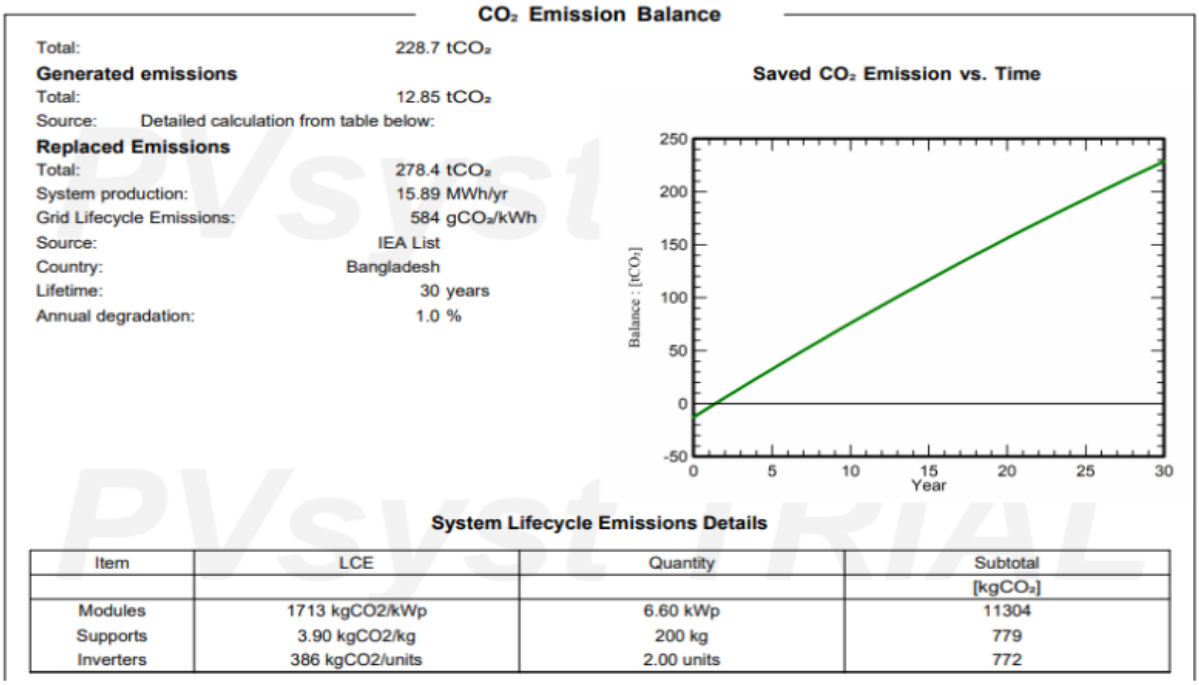
(Source: Author, From PV syst)

Figure 4.3.1.b: All of loss diagram from PV syst software.



(Source: Author)

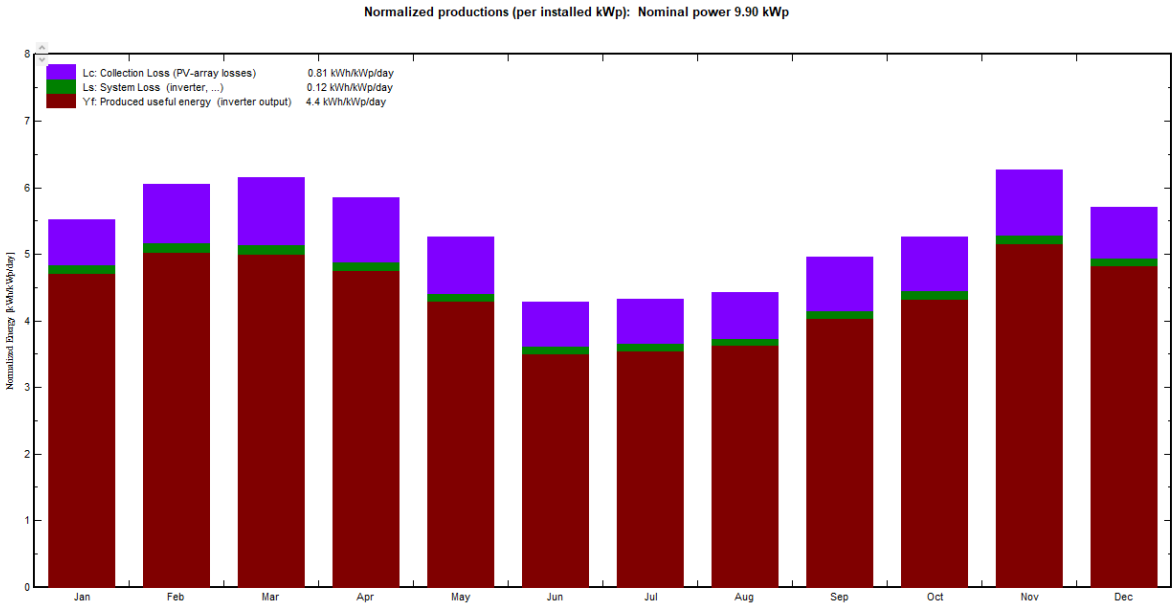
Figure 4.3.1.c: CO2 Emission Balance. From PV syst.



(Source: Author.)

There are both figure 4.3.1.b and figure 4.3.1.c show the total various losses and (CO2) emissions balance. This is very important for our environment because this solar system total 228.7 tCO2 saved emissions of CO2 balance.

Figure 4.3.1.d: Normalized productions (per installed kWp) and nominal power 9.9kWp.



(Source: Author. Create by PVsyst software.)

Figure 4.3.1.d: Normalized productions per installed kWp show that above total nominal power is 9.90 kWp and there are also show. Lc: Collection Loss (PV-array losses) = 0.81 kWh/kWp/day. Ls: System loss (inverter) = 0.12 kWh/kWp/day. Yf: Produced useful energy (inverter output) = 4.4 kWh/kWp/day.

4.4: Summery of this chapter four.

At first in this chapter present at point 4.1: Circuit design and formula of solar system and total calculation and measurement of roofs space and solar system because we have been work to government primary school`s rooftop site to implementation on-grid solar system. We are visited govt. primary school and therefore we highlight at point 4.2.2: Calculation of total solar panel and roofs space and we have done this. Then we present Total load calculation of a government primary school third floor prominent building and shown this chapter total Approximate cost calculation of tis on-grid solar system. Finally we try to analysis by the PVsyst software to make approximate result that is shown at point 4.3: Simulation and result of PV syst software. By this software we can make a full-fill various types of result like, cost analysis, payback period, Unit price, different types of losses, Carbon emissions balance and etc.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS.

5.1: Conclusion.

Due to the lack of electrical energy, that is why load shedding is the common issue of our country. But electrical energy is so much important for develop living standard. For this reason it is most necessity to supply electrical energy by otherwise sources. Electricity is not flowing at the rate at which the population is increasing day by day as a result demand is increasing on national grid and increases load shedding. Renewable energy is the best solution to make full-fill a huge quantity of electrical energy in this point of view. If we converting the solar energy to electrical energy by PV system that will be a great substitute and slow down over exploitation of national grid energy, that make a good result of our country`s economy. If the roofs of all government primary schools in Bangladesh can be converted by the on-grid solar system field, then the country will be able to meet a huge amount lack of electrical energy by sending additional electrical energy to the grid with full-fill demand for all of government primary schools. PV systems are now available for easy installation with all necessary accessories in a competitive market of Bangladesh. Day by day people going on interested to install the PV system in our country. PV system offer enormous benefits to countries with a good solar resource and could be deployed much faster than the current rate.

5.2: Findings from the Study.

This thesis book is highlighted on installing the on-grid PV solar system in government primary schools rooftop where utility grid is available. Since the utility grid is not enough to supply the electricity demand perfectly an alternate solution is needed to full-fill and lessen the pressure on the utility grid system and at the same time helping the full-fill the electricity demand. Finally we want to say that it can will be a great solution for our country and economy system.

5.3: Recommendations.

There are present something recommendations for on-grid PV solar system for government primary schools rooftop.

- Since it is proposed on government schools, if the government looks into the matter, it will bring a good result.

- Government should be attention to the renewable energy resources that will make a good result for our country and since the government primary schools rooftop is free so it will be an income source for our country.

- Day bay day CO2 is increasing that is why we are all of effected various problem so, for this reason we should make useful depend on renewable energy.

- Government should make a better policy and strictly apply to deploy solar system in every sector like Schools, Colleges, Universities, and offices.

- If we want to get good result then, quality must be assured during implementation for PV solar system.

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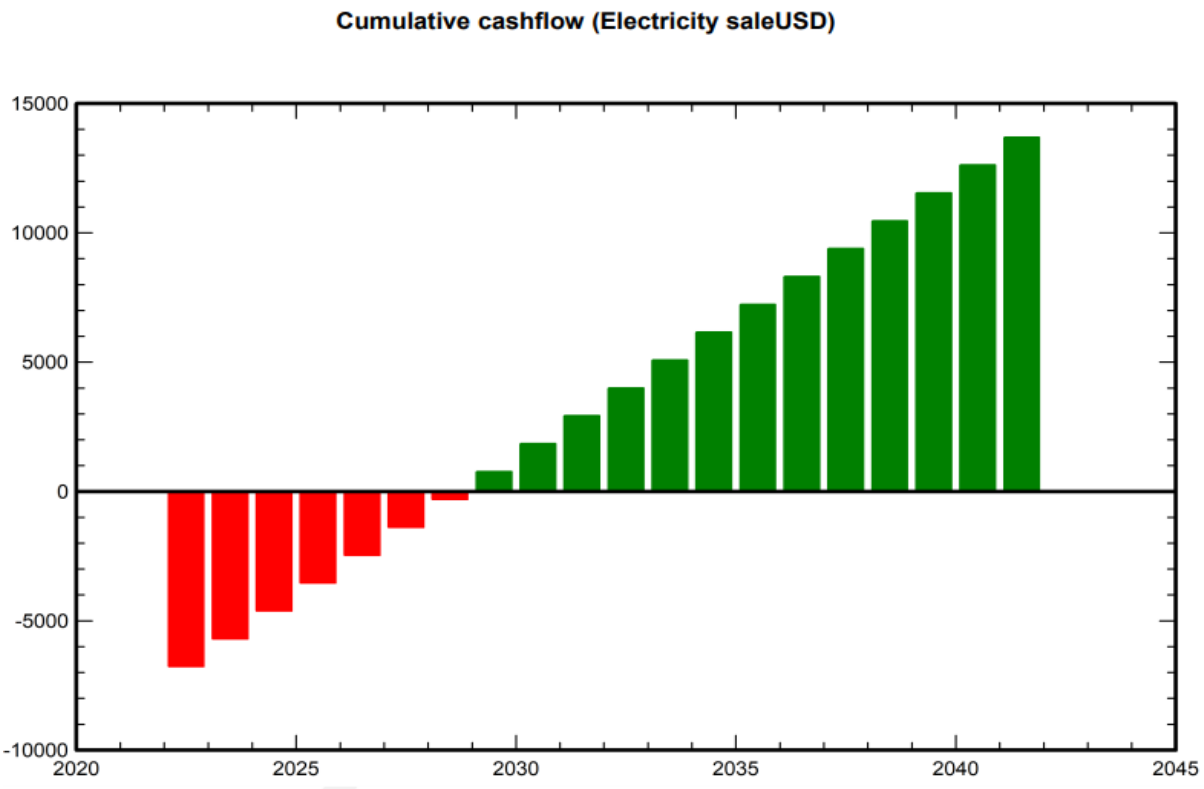
APPENDIX-A

Result obtained from PVSyst for 9.9 kWp on-grid solar PV system for Gazipur City Corporation



Here is highlight the cumulative cash flow for 9.9 kWp on grid solar system that is simulated result.

On grid solar system for Gazipur City Corporation area

Monthly Hourly sums for E_Grid [kWh]

	0H	1H	2H	3H	4H	5H	6H	7H	8H	9H	10H	11H	12H	13H	14H	15H	16H	17H	18H	19H	20H	21H	22H	23H
January	0	0	0	0	0	0	0	39	103	158	197	214	211	198	165	112	50	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	37	94	148	185	198	202	190	163	117	59	2	0	0	0	0	0	0
March	0	0	0	0	0	0	3	52	114	160	192	208	215	205	173	131	70	14	0	0	0	0	0	0
April	0	0	0	0	0	0	16	61	113	157	183	192	190	175	146	106	56	16	0	0	0	0	0	0
May	0	0	0	0	0	0	23	63	108	143	169	179	177	155	132	97	54	17	0	0	0	0	0	0
June	0	0	0	0	0	1	19	50	78	106	125	139	136	132	112	80	47	17	1	0	0	0	0	0
July	0	0	0	0	0	0	15	46	83	109	133	146	145	136	115	87	53	19	1	0	0	0	0	0
August	0	0	0	0	0	0	14	50	90	123	144	149	151	137	111	82	48	15	0	0	0	0	0	0
September	0	0	0	0	0	0	13	54	97	133	158	173	162	145	123	90	44	5	0	0	0	0	0	0
October	0	0	0	0	0	0	11	62	114	159	182	196	186	166	129	87	35	0	0	0	0	0	0	0
November	0	0	0	0	0	0	1	71	137	185	214	220	218	198	156	98	34	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	49	116	171	208	222	220	199	158	100	36	0	0	0	0	0	0	0
Year	0	0	0	0	0	1	115	636	1246	1753	2091	2237	2212	2035	1683	1188	585	105	2	0	0	0	0	0

Here is present above the table on-grid solar system for Gazipur City Corporation monthly and hourly sum for E_Grid kWh.

APPENDIX-B

Result obtained from PVSyst for 9.9 kWp on-grid solar PV system for Gazipur City Corporation.

Here present the summary result of project, system, general parameter, PV array characteristics, array losses and final result.

Project summary

Geographical Site
Gazipur City Corporation
Bangladesh

Situation
Latitude 24.00 °N
Longitude 90.42 °E
Altitude 11 m
Time zone UTC+6

Project settings
Albedo 0.20

Meteo data
Gazipur City Corporation
Meteonorm 7.3 (1981-2010), Sat=100% - Synthetic

System summary

Grid-Connected System

No 3D scene defined, no shadings

PV Field Orientation
Fixed plane
Tilt/Azimuth 30 / 0 °

Near Shadings
No Shadings

User's needs
Unlimited load (grid)

System information

PV Array
Nb. of modules 30 units
Pnom total 9.90 kWp

Inverters
Nb. of units 1.5 units
Pnom total 7.50 kWac
Pnom ratio 1.320

Results summary

Produced Energy 15.89 MWh/year
Specific production 1605 kWh/kWp/year
Perf. Ratio PR 82.44 %

Array losses

Thermal Loss factor
Module temperature according to irradiance
Uc (const) 20.0 W/m²K
Uv (wind) 0.0 W/m²K/m/s

DC wiring losses
Global array res. 217 mΩ
Loss Fraction 1.5 % at STC

Module Quality Loss
Loss Fraction -0.8 %

Module mismatch losses
Loss Fraction 2.0 % at MPP

Strings Mismatch loss
Loss Fraction 0.1 %

IAM loss factor
Incidence effect (IAM): Fresnel smooth glass, n = 1.526

0°	30°	50°	60°	70°	75°	80°	85°	90°
1.000	0.998	0.981	0.948	0.862	0.776	0.636	0.403	0.000

General parameters

Grid-Connected System — **No 3D scene defined, no shadings**

PV Field Orientation
Orientation
Fixed plane
Tilt/Azimuth 30 / 0 °

Models used
Transposition Perez
Diffuse Perez, Meteonorm
Circumsolar separate

Horizon
Free Horizon

Near Shadings
No Shadings

User's needs
Unlimited load (grid)

PV Array Characteristics

PV module

Manufacturer	Generic
Model	ZT-330P
(Original PVsyst database)	
Unit Nom. Power	330 Wp
Number of PV modules	30 units
Nominal (STC)	9.90 kWp
Modules	3 Strings x 10 In series
At operating cond. (50°C)	
Pmpp	8.96 kWp
U mpp	344 V
I mpp	26 A

Inverter

Manufacturer	Generic
Model	Equinox EQX 5000-2S
(Original PVsyst database)	
Unit Nom. Power	5.00 kWac
Number of inverters	3 * MPPT 50% 1.5 units
Total power	7.5 kWac
Operating voltage	240-480 V
Pnom ratio (DC:AC)	1.32

Total PV power

Nominal (STC)	10 kWp
Total	30 modules
Module area	58.2 m²
Cell area	52.5 m²

Total inverter power

Total power	7.5 kWac
Nb. of inverters	2 units
	0.5 unused
Pnom ratio	1.32

Cost of the system

Installation costs

Item	Quantity units	Cost USD	Total USD
PV modules			
ZT-330P	30	216.07	6'482.14
Inverters			
Equinox EQX 5000-2S	2	595.23	892.85
Installation			
Transport	1	119.50	119.50
Wiring	1	119.50	119.50
Settings	1	119.00	119.00
Grid connection	1	119.50	119.50
Total			7'852.49
Depreciable asset			7'374.99

Operating costs

Item	Total USD/year
Maintenance	
Cleaning	95.24
Total (OPEX)	95.24

System summary

Total installation cost	7'852.49 USD
Operating costs	95.24 USD/year
Produced Energy	15.9 MWh/year
Cost of produced energy (LCOE)	0.031 USD/kWh

APPENDIX-C

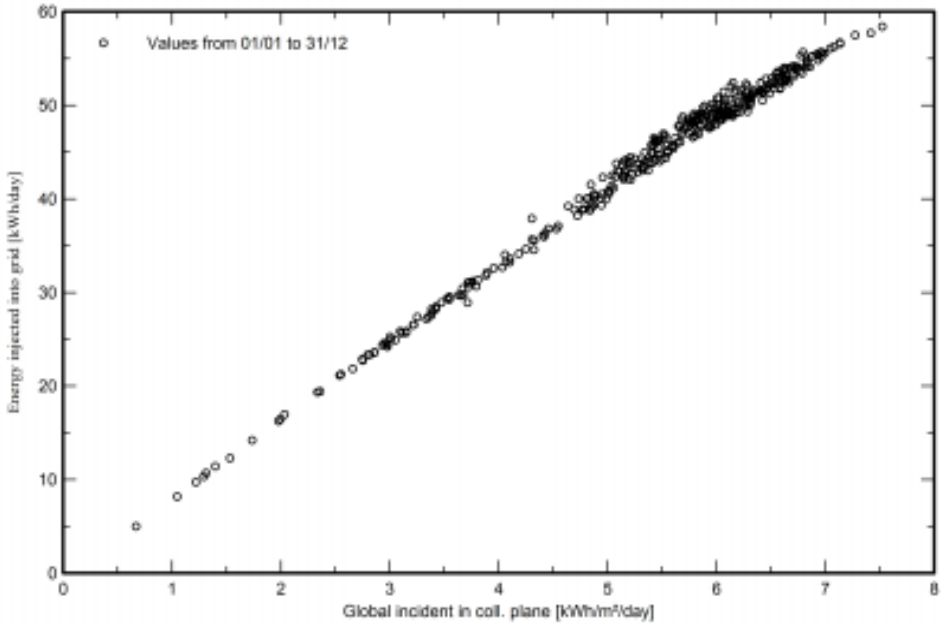
Result obtained from PVSyst for 9.9 kWp on-grid solar PV system for Gazipur City Corporation.

Here we present the special graph of Daily Input and Output and system output power distributions.

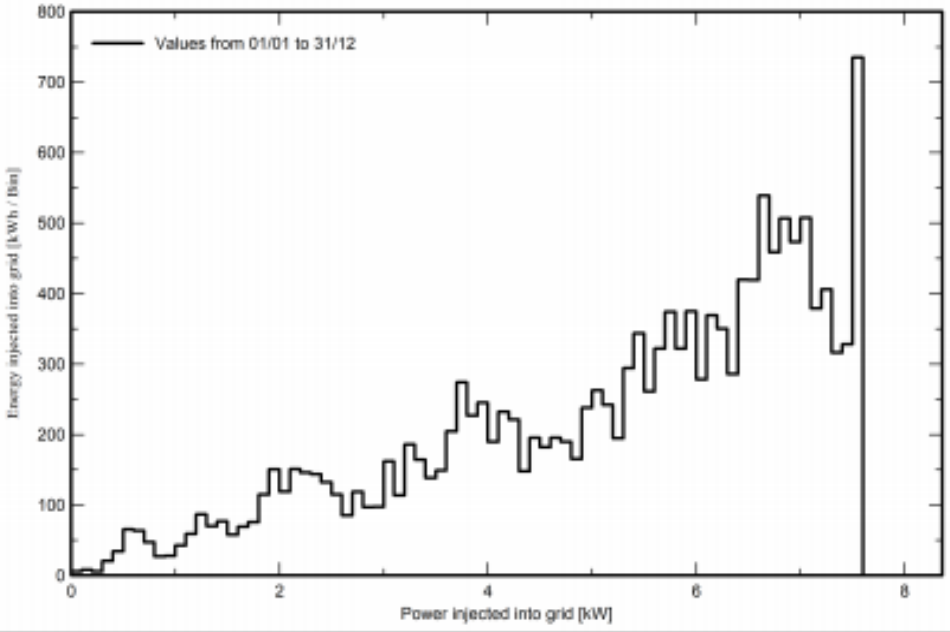
PVsyst V7.1.2
VC0, Simulation date:
05/01/21 06:42
with v7.1.2

Special graphs

Daily Input/Output diagram

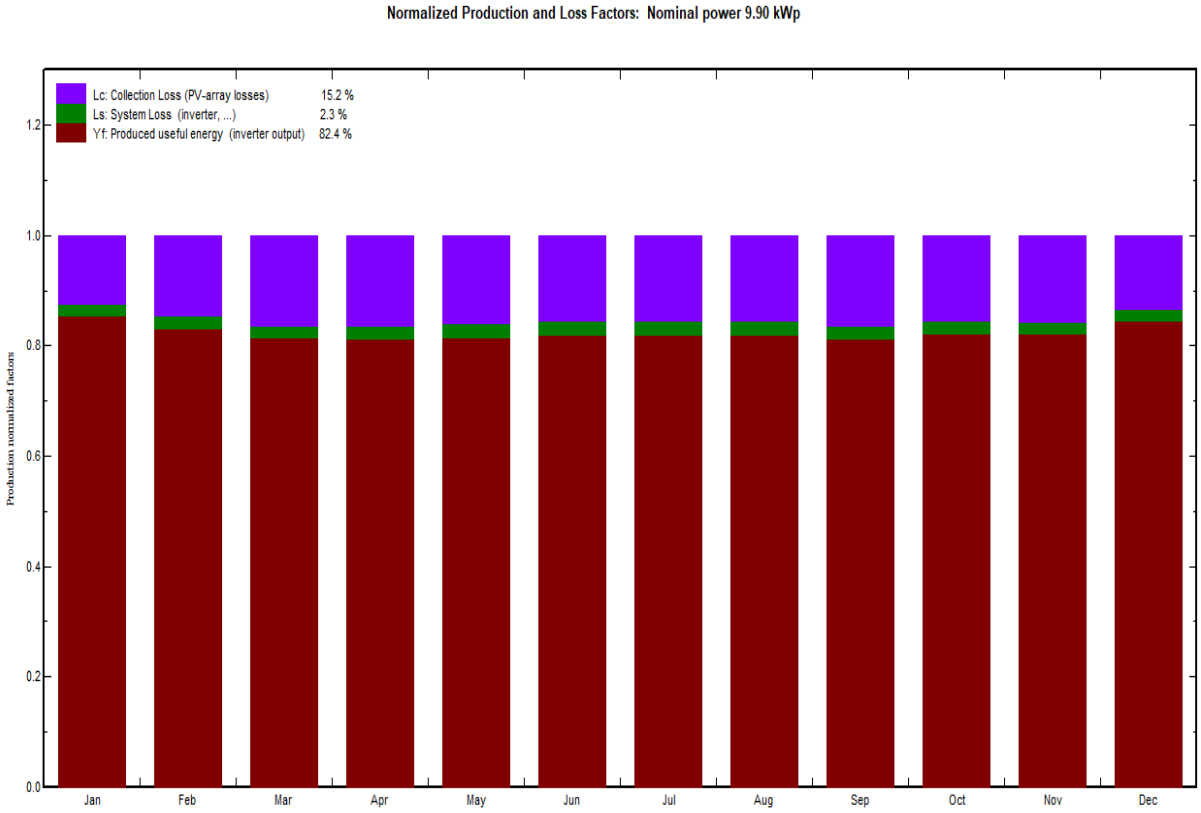


System Output Power Distribution



APPENDIX-D

Result obtained from PVSyst for 9.9 kWp on-grid solar PV system for Gazipur City Corporation.



Detailed economic results (USD)

	Gross income	Run. costs	Deprec. allow.	Taxable income	Taxes	After-tax profit	Cumul. profit	% amorti.
2022	1'173	95	0	1'077	0	1'077	-6'775	13.7%
2023	1'173	95	0	1'077	0	1'077	-5'698	27.4%
2024	1'173	95	0	1'077	0	1'077	-4'621	41.2%
2025	1'173	95	0	1'077	0	1'077	-3'543	54.9%
2026	1'173	95	0	1'077	0	1'077	-2'466	68.6%
2027	1'173	95	0	1'077	0	1'077	-1'389	82.3%
2028	1'173	95	0	1'077	0	1'077	-311	96.0%
2029	1'173	95	0	1'077	0	1'077	766	109.8%
2030	1'173	95	0	1'077	0	1'077	1'843	123.5%
2031	1'173	95	0	1'077	0	1'077	2'921	137.2%
2032	1'173	95	0	1'077	0	1'077	3'998	150.9%
2033	1'173	95	0	1'077	0	1'077	5'075	164.6%
2034	1'173	95	0	1'077	0	1'077	6'153	178.4%
2035	1'173	95	0	1'077	0	1'077	7'230	192.1%
2036	1'173	95	0	1'077	0	1'077	8'307	205.8%
2037	1'173	95	0	1'077	0	1'077	9'385	219.5%
2038	1'173	95	0	1'077	0	1'077	10'462	233.2%
2039	1'173	95	0	1'077	0	1'077	11'539	247.0%
2040	1'173	95	0	1'077	0	1'077	12'617	260.7%
2041	1'173	95	0	1'077	0	1'077	13'694	274.4%
Total	**23'451**	**1'905**	**0**	**21'547**	**0**	**21'547**	**13'694**	**274.4%**