A BRIEF STUDY OF THE PROSPECT OF SOLAR ENERGY IN GENERATION OF ELECTRICITY IN BANGLADESH

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Abstract-This study examines the average annual sunlight hours in Bangladesh and was compared with other developed countries like Germany and Spain, which are notable for their development in renewable energy sector. Suitable locations for solar power plants are proposed based on the maximum efficiency factors like sunlight hours, cloud coverage limits, amount of solar radiation received, type of plane etc. Possible implementable solar technologies like concentrating solar power(CSP), photovoltaic cells(PV) and Integrated Solar Combined Cycle(ISCC) are discussed with their optimum capacity, efficiency, storage facility and cost per unit power. Some social, economic and environmental constraints regarding the implementation of solar technology are highlighted and some possible solutions are offered.

Key words: Solar energy, sunshine hour, concentrating solar power, photovoltaic cell, solar radiation, cloud coverage.

1. Introduction

The amount of energy we receive from the sun is enormous. At the outer atmosphere of the Earth we receive about 1300 watts worth of power per hour per meter every day. Around 30% of this power is reflected back which still results in a staggering 4.2 Kilowatt-hours of energy per meter each day. Thus it can be safely said that each square meter collects the approximate energy equivalent of almost a barrel of oil each year. The amount of solar energy reaching the surface of the planet is so vast that in one year it is about twice as much as will ever be obtained from all of the Earth's non-renewable resources of coal, oil, natural gas, and uranium combined. Deserts with little cloud cover gets nearly 50% more energy per square meter and also equatorial areas have a higher sunshine hour. As a result solar energy can be harnessed at different levels depending upon geographical location of areas.

2. Solar Power in Bangladesh

Most of the generated power in Bangladesh comes from coal, diesel and gas driven power stations. However the reserve of such natural resources (natural gas) are being depleted at an alarming rate, with current estimates showing that it will last a few decades or so at the current consumption rate. This together with the fact that over 70% of Bangladesh lies outside the national grid should be of grave concern. Even then the areas which are within the grid have inconsistent and often unreliable power supply.The country has a total demand of 7000 MW per day in response to which only 4500~4600 MW can be produced, despite having the capability of producing 6700MW per day. This is mostly because of the outdated and worn out equipment in the countries 81 stations.

Bangladesh is a semi-tropical region lying in northeastern part of South Asia gets abundant sunlight year round. The average bright sunshine duration (figure 1 and table1) in Bangladesh in the dry season is about 7.6 hours a day, and that in the monsoon season is about 4.7 hours. The highest sunlight hours received is in Khulna with readings ranging from 2.86 to 9.04hours and in Barisal with readings ranging from 2.65 to 8.75 hours. These are very good statistics when compared to the 8 hours of daylight in Spain which produced 4 GW of energy covering 2.7% of national demand by the end of 2010. Moreover Germany produces 18 GW of energy which is 2% of their national demand with only half the solar radiation received by Bangladesh.Thus solar power could be used in Bangladesh if possible not as a direct generation scheme but in conjunction with

the existing infrastructure(combined cycle power station) .

Ideal locations for a solar power plant will have to be arid, flat lands with minimum cloud cover, high solar radiation availability and exhibit high average sunlight hours throughout a year. Mostly three different types of landscapes are found in Bangladesh floodplains,terraces and hills with floodplains being the most frequent (around 80% of the total landscape). Parts of Bangladesh like Khulna, Barisal and Rajshahi shows the trend of receiving a higher than average amount of solar radiation (figure 2 and table 2)when compared to the rest of the country. Although there is a trend of the amount solar radiation received decreasing during the monsoon season the annual average sunlight hour and solar radiation is sufficient in most areas of Bangladesh for the operation of small scale SHS(Solar Home Systems) .In fact the annual solar radiation availability in Bangladesh is as high as 1700kwh/m².During the monsoon season the average solar radiation availability across the country is around 174.2 cal/cm²/min. Some parts of Barisal and Khulna even have high radiation and sunlight hour figures for the ideal operation of grid connected PV's and even CSP stations(Concentrated Solar Power).Most solar radiation is received in Khulna with readings varying from 180.30 to 318.70cal/cm²/min and in Barisal with reading varying from 185.5 to 348.9cal/cm²/min.The above mentioned areas also receive a lot less cloud coverage (figure3 and table 3)except during the monsoon season, throughout the year. The lowest cloud coverage is in Rajshahi and Khulna, with readings varying from 0.34 to 6.36 okta in Rajshahi and 0.32 to 6.97 okta in Khulna. During the monsoon season the average cloud coverage across the country is 5.42 okta.

3. Possible schemes

The possible schemes that could be implemented in Bangladesh are:

3.1 CSP(*Concentrating Solar Power*): This technology has been in use from the 1960's and is well adjusted for large scale power generation as in solar power plants.Concentrating Solar Power (CSP) technology has experienced a revival in its use lately with countries around the world using it as basis to build new power plants. This technologyuses lenses or mirrors and tracking systems to focus a large area of sunlight onto a small area. The concentrated sunlight is focused onto either high efficiency photovoltaic chips or onto a heat transfer medium as in a conventional thermal power plant. The steam produced is in turn used to rotate a turbine coupled toan electric power generator. CSP systems work best at about 5.5KWH/square meter/day. Currently the cost of generating power using CSP technology is around15 to 23 BDT per watt.Concentrating technologyexists mainly in four forms, each having different levels of efficiency due to the differences in the way they track and focus sunlight.Some of them even offer storage facilities since normal operation at night time is not possible.

3.2 Integrated Solar Combined Cycle (ISCC): This is ahybrid system combining solar power towers with natural gas power generators currently used in many power plants.This results in a system that can continuosly generate electricity even when sunlight is absent.ISCC is in essence another form of concentrating solar technology.

3.3Photo-voltaicCells(PV): In general, a solar cell or photovoltaic cell (PV) is a solid state electrical device that converts light into electric current using the photoelectric effect.Materials presently used for photovoltaic solar cells include mono-crystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium selenide/sulfide. Different materials offer varying level of efficiencies, with the current average efficiency of a solar cell ranging from 8%-20%. Historically, most PV panels have been used for off-grid purposes, thus it can be seen as a means of avoiding construction of long and expensive power lines to remote areas.Off-grid PV systems have traditionally used rechargeable batteries to store excess electricity which can run the cell for a few hours in the absence of sunlight.

Figure 3: Average sunlight hour in six divisions

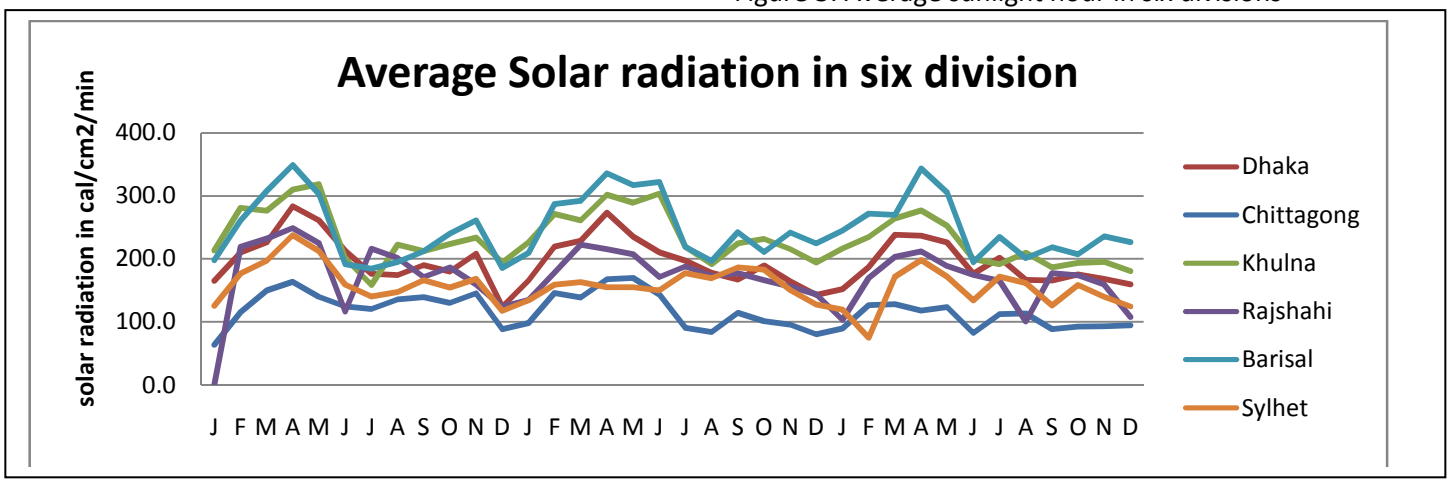

Figure 1:Average solar radiation in six divisions.

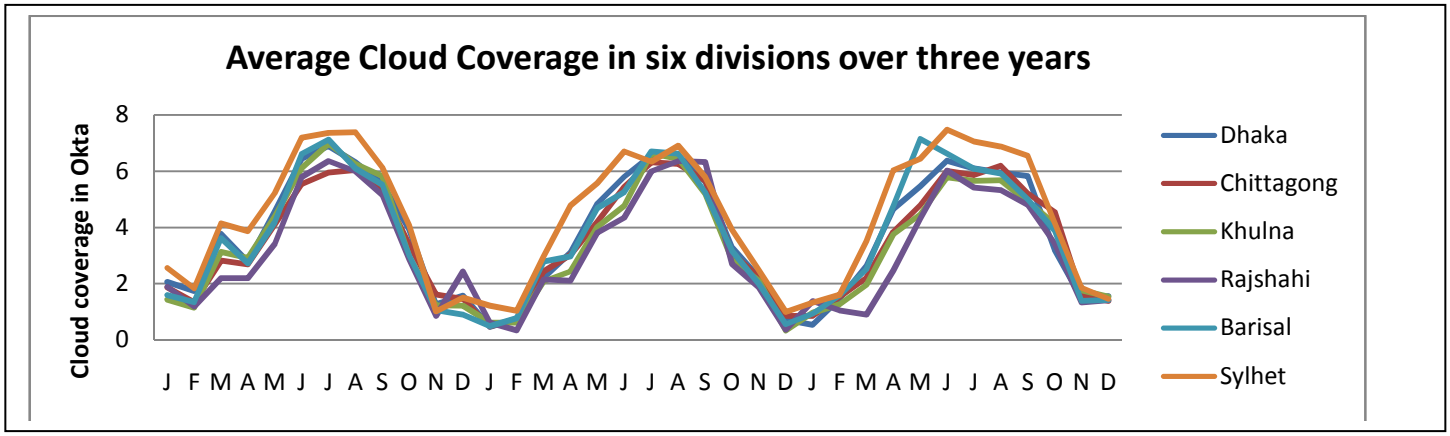

Figure 2: Average cloud coverage in six divisions over three years

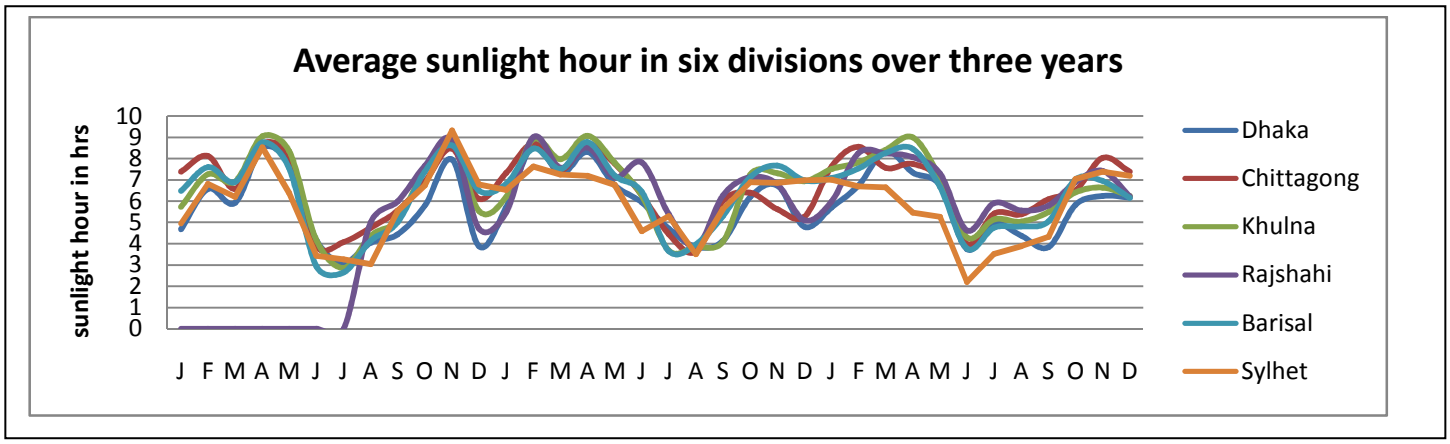

Table1: Showing Data of monthly average sunshine hour in six different divisions over a period of 3 years

Year	Months	Dhaka	Chittagong	Khulna	Rajshahi*	Barisal	Sylhet
2008	January	4.68	7.39	5.73	0	6.48	4.94
	February	6.57	8.12	7.26	0	7.6	6.81
	March	5.92	6.57	6.91	0	6.9	6.2
	April	8.49	8.7	9.04	0	8.75	8.52
	May	7.75	8.14	8.34	0	7.53	6.37
	June	4.17	3.88	4.16	0	2.93	3.43
	July	3.1	4.07	2.86	0	2.65	3.26
	August	4.04	4.75	4.38	5	4.14	3.03
	September	4.43	5.55	5.11	5.98	5.01	5.54
	October	5.79	6.91	7.46	7.66	7.39	6.73
	November	7.95	8.47	8.81	8.87	8.61	9.32
	December	3.88	6.11	5.53	4.71	6.49	6.78
2009	January	5.71	7.32	6.19	5.48	6.81	6.52
	February	8.66	8.71	8.91	9	8.47	7.63
	March	7.27	7.44	7.97	7.56	7.51	7.24
	April	8.31	8.69	9.07	8.52	8.77	7.18
	May	6.75	7.76	7.8	7.11	7.2	6.77
	June	5.94	6.28	6.25	7.82	6.43	4.59
	July	4.7	4.45	3.68	5.39	3.66	5.3
	August	3.85	3.62	3.85	3.85	3.97	3.51
	September	4.13	6.01	4.1	6.27	5.31	5.64
	October	6.19	6.39	7.24	7.12	7.13	6.89
	November	6.73	5.62	7.31	6.8	7.67	6.86
	December	4.79	5.26	6.93	5.1	6.97	6.98
2010	January	5.7	7.63	7.5	5.99	7.08	7
	February	6.74	8.55	7.82	8.25	7.54	6.69
	March	8.35	7.56	8.41	8.24	8.25	6.65
	April	7.34	7.75	8.99	8.06	8.45	5.46
	May	6.74	6.97	7.08	7.29	6.66	5.26
	June	3.74	3.99	4.3	4.62	3.78	2.19
	July	4.93	5.42	5.14	5.91	4.75	3.52
	August	4.37	5.38	5.04	5.56	4.81	3.88
	September	3.83	6.09	5.49	5.79	5.05	4.32
	October	5.82	6.49	6.4	6.89	7.01	7.03
	November	6.24	8.03	6.63	7.42	6.94	7.39
	December	6.17	7.38	6.24	6.22	6.15	7.18

**Data of first 7 months of 2008 for Rajshahi was unavailable*

Table2: Showing Data of monthly average solar radiation in six different divisions over a period of 3 years

Year	Month	Dhaka	Chittagong	Khulna	Rajshahi*	Barisal	Sylhet
2008	January	164.9	63.40	213.10	0.00	197.5	125.3
	February	209.8	115.40	281.10	219.30	260.4	176.4
	March	225.7	150.00	276.50	232.30	307.8	196.8
	April	283.3	163.80	310.10	249.10	348.9	237.5
	May	261.1	139.60	318.70	225.30	302.5	212.0
	June	212.4	124.30	201.00	116.40	191.3	158.7
	July	176.2	120.20	158.30	216.20	184.3	140.3

	August	174.1	135.90	222.40	201.30	195.0	147.3
	September	189.6	139.20	212.30	171.30	211.7	166.1
	October	179.7	130.30	223.30	186.70	239.9	154.4
	November	208.1	145.40	233.50	159.50	261.1	168.2
	December	123.7	88.40	193.70	124.00	185.5	117.4
2009	January	165.6	98.10	226.00	134.50	209.3	133.9
	February	219.1	145.70	271.50	178.10	287.1	159.0
	March	228.3	138.90	261.40	222.80	292.1	163.0
	April	273.1	167.60	301.80	215.30	335.8	154.7
	May	235.1	169.80	289.10	207.60	317.1	155.0
	June	210.3	143.40	303.60	171.40	321.9	149.7
	July	197.0	90.50	218.80	188.00	218.6	176.9
	August	177.5	83.80	191.50	172.90	196.5	169.2
	September	166.8	114.40	224.70	177.60	242.1	186.1
	October	189.1	101.00	231.60	166.4	210.9	182.5
	November	164.0	95.70	215.40	156.30	241.8	150.3
	December	142.5	80.00	193.70	143.80	224.4	127.5
2010	January	151.5	89.50	216.50	103.27	245.0	119.1
	February	186.7	126.70	234.60	169.85	271.5	74.6
	March	238.2	128.30	264.40	203.10	269.8	171.7
	April	236.7	118.00	276.70	211.93	343.4	197.8
	May	225.8	123.40	252.50	188.70	305.2	171.5
	June	176.0	82.20	199.30	174.35	194.7	133.9
	July	201.6	112.20	191.60	165.30	234.4	171.4
	August	166.3	113.30	209.80	100.43	201.1	161.5
	September	165.5	88.20	186.50	177.39	218.5	125.7
	October	175.2	92.30	193.20	173.69	207.0	158.3
	November	168.0	92.70	195.20	158.97	235.5	139.6
	December	159.2	94.30	180.30	108.00	226.4	124.3

*****Data for the month of January,2008 for Rajshahi was unavailable*

Table3: Showing Data of monthly cloud coverage in six different divisions over a period of 3 years

Year	Month	Dhaka	Chittagong	Khulna	Rajshahi	Barisal	Sylhet
2008	January	2.06	1.86	1.43	1.89	1.59	2.55
	February	1.74	1.33	1.14	1.18	1.34	1.82
	March	3.78	2.81	3.12	2.2	3.61	4.14
	April	2.78	2.68	2.9	2.2	2.72	3.86
	May	4.58	4.09	4.37	3.41	4.18	5.22
	June	6.44	5.54	6.1	5.79	6.61	7.2
	July	6.9	5.95	6.97	6.36	7.13	7.37
	August	6.32	6.04	6.25	6	6.1	7.39
	September	5.56	5.35	5.82	5.15	5.52	6.13
	October	3.94	3.39	2.95	2.85	3	4.07
	November	1.26	1.61	1.22	0.85	1.05	1
	December	1.56	1.45	1.21	2.43	0.89	1.49
2009	January	0.46	0.47	0.61	0.61	0.48	1.21
	February	0.74	0.73	0.6	0.34	0.76	1.02
	March	2.2	2.43	2.07	2.15	2.78	2.96
	April	3.11	3.02	2.43	2.1	2.96	4.78
	May	4.85	4.19	4.01	3.81	4.69	5.57
	June	5.81	5.43	4.76	4.35	5.26	6.7
	July	6.57	6.31	6.63	6	6.71	6.34
	August	6.58	6.25	6.44	6.36	6.62	6.91

	September	5.62	5.66	5.18	6.33	5.25	5.79
	October	3.29	3.08	2.82	2.7	3.16	3.91
	November	2.22	2.22	2.11	1.87	1.99	2.47
	December	0.71	0.84	0.32	0.36	0.55	0.98
2010	January	0.53	0.84	0.96	1.38	0.93	1.31
	February	1.45	1.52	1.25	1.04	1.58	1.6
	March	2.63	2.2	1.95	0.9	2.51	3.51
	April	4.66	3.84	3.75	2.47	4.76	6.03
	May	5.46	4.78	4.45	4.31	7.15	6.44
	June	6.38	6	5.77	6.02	6.62	7.48
	July	6.1	5.85	5.65	5.41	6.09	7.06
	August	5.95	6.18	5.67	5.33	5.92	6.88
	September	5.83	5.21	4.9	4.8	5	6.54
	October	3.2	4.55	4.12	3.44	3.89	4.16
	November	1.48	1.6	1.75	1.33	1.38	1.85
	December	1.55	1.38	1.53	1.41	1.41	1.45

Table4:Comperative study of different kinds of solar power technology

Technology	Short Description	Optimum capacity(estimated)	Efficiency(solar to electric)	Storage	Pros/Constraints
Parabolic Trough	Long, curved mirrors (parabolic trough) pivot sunlight onto tubes filled with heat transfer medium (water or oil).	150-250 MW.	Annual average efficiency is at 12-14%	Molten salt heat storage system.	Storage, well understood technology, needs water for efficient cooling.
Fresnel Reflectors	Same as Parabolic Trough but uses flat mirror strips instead of curved mirrors.	60-125 MW(e)	Less than 12%	Heat Storage can be used to some extent but has not been perfected.	Less efficient than other CSP systems.Cheap.
Dish Stirling	It uses a parabolic mirror which focuses heat directly on a Stirling engine, which operates using any heat source	Around 25 KW per dish.	Annual average is around 22%.The newest systems have 31.5% conversion efficiency.	Does not accommodate thermal storage.	High efficiency. No thermal storage.
Solar Power Tower	It consists of an array of dual-axis tracking reflectors (heliostats) that concentrate light on a central receiver atop a tower.The receiver contains a heat transfer medium(sea water)	Around 30 MW.	Annual average is around 12%.	Molten heat storage system.	Cheaper than solar trough. Needs water for efficient cooling

Solar cells the most frequently used form solar technology and can be used for a wide variety of applications such as solar power plants, in the rooftops of buildings, on street lights, etc. Solar cells can be also be augmented with concentrating technology to acquire even higher efficiencies This technology uses mirrors or lenses to focus sunlight on high-efficiency photovoltaic chips. The extra sunlight makes it worth the expense of making a more efficient higher complexity chip because each chip can convert more sunlight to electricity, with conversion efficiencies often twice as high as the efficiencies of conventional solar panels. Its limitations are that it does not work as well as conventional panels in diffuse light through clouds (because the light cannot be focused) so they are only appropriate for areas with very little cloud cover and also requires expensive cooling mechanisms.

4. Advent and current status of Solar energy application in Bangladesh

In 1988, Bangladesh Atomic Energy Commission (BAEC) installed several PV(photovoltaic cells) for the first time for experimental purposes. The first significant PV related project was undertaken in Norshingdi with financial support of France. In this program three battery charging stations with capacity of 29.4kWp and a number of solar home systems (SHS) of capacity 32.586kWp were installed. Since 1996 popularity of SHS have been increasing mostly due to the efforts of Grameen Shakti (GS) and several other notable NGO's like CMEC and BRAC. Rural Electrification Board(REB) with support from Infrastructure Development Company Limited (IDCOL), GS and other NGO's are distributing SHS in the rural areas.. The Power Development Board(PDB) has already installed 11KW power in the Chittagong hill tracts area and 230 W solar power in Angorpot.PDB has further plans of installing 10MW solar plant in Sarishabari,1MW in Rajshahi, and about 2-4 MW in Rajbari , Godabari areas.

As of the year 2011 the number of households powered by solar energy in Bangladesh has passed the one million mark. This is a noteworthy achievement considering only 7000 households were using solar panels in 2002. In August 2009, the World Bank agreed to loan Bangladesh $130 million to install solar energy panels to power 300,000 households. That loan as well as low-cost government/private sector financing to install solar PV's , have fueled this fast growth. The government has also expressed its desire to build several solar power stations including a 20 MW concentrating solar power plant inside the Kaptai hydroelectric power station, to be financed by ADB.

Government incentives for companies setting up solar plants include a 15-year tax holiday and exemption from paying import duty on equipment. Foreign investors get exemptions on royalties, technical knowhow, technical assistance fees and facilities for their repatriation of profits. In 2010 the government also made it mandatory for all newly constructed domestic and commercial buildings to have solar systems installed on rooftops.

5.Limitations

Construction of solar power stations requires extensive infrastructure and equipment. These require a staggering amount of fund most of which will have to be borrowed from foreign donors. Most of the families in the country also will not be able to afford solar cells for their home(especially in the rural areas).Moreover Bangladesh doesn't possess the necessary technology and raw materials to manufacture the photovoltaic cells (PV), reflectors and other auxiliaries, all of which will have to be imported. Maintenance and repairing will also be an issue due to the lack of experience of the technicians in this sector..A solar power plant will need hundreds of hectares of area cleared for its construction which will naturally have adverse effects on the environment. Security is also a concern since PV's are very expensive and is likely to be stolen at the first chance from the roof of a building, from the streetlights and from other installations which are within public reach..Also during the winter season and sometimes during the monsoon season clovd cover icreases drastically thereby limiting sunlight availability and thus might affect the generation scheme.All our country's limitations aside, photovoltaic cells have a very low efficiency.

6. Possible Remedies and Concluding remarks

First of all social awareness should be built up by running media awareness programs like talk shows and arranging seminars, especially in colleges and universities to motivate the young generation. Reduced taxes and removal of any tariffs on accessories vital to this sector could help reduce the expense to a reasonable level. Training programs conducted by experts from countries notable for their advancement in solar energy sector could be arranged. Government can provide financial incentives, aid packages, offer technical and legal support and even subsidize organizations dealing or wanting to set up in the solar sector.

Many countries like Denmark, Spain, and Germany have already declared national policies to generate at least 20% of their national demand through renewable sources and by 2050 become completely powered by renewable energy. The Bangladesh government has also developed a policy to meet 5% of the country's electricity demand by 2015 and 10% by 2020.Such actions are indeed commendable but even more needs to be done for Bangladesh to meet the increasing demand of electricity for economic development.

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