Performance Analysis of Building Integrated Photovoltaic Application with Tilt and Azimuth Angle in Bangladesh

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Abstract

This paper analyzes the dependency of power output of the building integrated photovoltaic application in Bangladesh on various tilt and azimuth angle. Again this paper shows the temperature dependency of the output power of the building integrated photovoltaic application in Bangladesh. From the analysis, it is seen that if tilt angle is decremented from 90 deg to 1 deg, the power of proposed arrays is incremented by 7.88

***Index terms*— :** tilt angle, azimuth angle, BIPV, solar irradiance.

1 Introduction

he BIPV application is a very important issue to overcome the world energy crisis. Now the building owners not only can fulfil their electricity demand but also can sell the surplus energy produced following this advanced system. Hence this BIPV system is getting highly preferable to the building owners for fulfilling the energy demand. According to the International Energy Agency (IEA), PV-suitable surfaces can be increased by about 35% incorporating BIPV on building facades [1], [2].

The performance of the BIPV is highly dependent on the tilt and azimuth angle. Since BIPV is related with fixed angle orientation of the solar modules, the optimum possible tilt angle orientation should be considered before building construction. For this reason this paper highlights the influence of tilt and azimuth angle on the BIPV application considering time and temperature issue.

2 II.

3 Solar Irradiance

Solar radiation is a very important factor that directly affects the solar cell output performance. Fig. 1 shows the radiation spectrum for the extraterrestrial space (AM0) & for the sea level or earth's surface (AM1.5). The irradiated solar energy is 1.353kW/m2 at the average distance between sun and the earth. The irradiation considered for the earth's surface is approximately1kW/m 2 which is a reference value since it depends on many factors. The AM1.5 is a standard for the PV device whose surface is tilted at 37° facing the sun rays [4].

A solar cell is mainly designed for absorption of a portion of the total radiation spectrum. From the Fig. 1, it is seen that a large amount of irradiance spectral is available in the visible spectrum (390nm-700nm) which stands in the opposition of the UV (<390nm) and infrared light (>750nm). PV solar cells are designed for the absorption of the visible spectrum only [3], [5]. The solar irradiation exposed to the PV array for fixed position is calculated from the following equations [6].r d s G G G + = (1)

Where, G s is total solar irradiation in kW/m 2 , G d is direct component of solar irradiation in kW/m 2 and G r is diffuse component of Solar Irradiation in kW/m 2 . ? ? ? ? ? ? ? ? ? ? ? ? ? ? (2)

Where, H is sun elevation, ? is oblique angle of the sun in radian, ? is azimuth angle, ? is declination of the sun in radian, ? n is north latitude, ? is hour angle in degree, G od is direct irradiation in radian. ? ? ? + + = o or r G G G (3)

Where, G or is diffuse (horizontal) irradiation in radian, G o is global horizontal irradiation in kW/m 2 . The sun elevation is given by (4) [6].) sin sin cos cos (cos sin 1 L D T D L H + = ? (**4**)

Where L is latitude in degree, D is declination of the sun in degree, T is hour angle in degree [6].

From Table 1, daily average sunshine hours are obtained from which the idea of average amount of solar power generation can be achieved. This type of statistics can help to determine the optimum tilt angle for grid connected building integrated photovoltaic application. Again, Fig. 2 represents the practical data curve of the solar irradiance against time which is obtained at KUET campus of Khulna city at 7th March, 2012. Since it is not possible to move the PV panel for BIPV system, it is needed to analyze the yearly performance to obtain optimum average solar irradiation with consideration of tilt and azimuth angles. For a fixed orientation of PV panels the optimum tilt angle is calculated mathematically given by Eq. 5 [8].

4)) ((

1 = ? = i G d d n i tt ? (5)

Where G tt (i) is the total irradiance for i hours and n is the total number of hours.

From Fig. 3, it is seen that there are 4 modules oriented at different slopes which can be taken as a model to analyze experimentally, where the researcher found that the monthly solar irradiation and temperature is 131kW/m 2 and 25°C respectively. that the horizontal global radiation is increased for decrement of latitudes.

5 IV. Simulation of Array at Various Tilt and Azimuth Angles

For simulation purpose two proposed arrays are taken in which each array consists of 50 strings in parallel and each string consists of 20 modules in series. The module taken for simulation is Solarex MSX-64. From the simulation study, eight various curves are obtained. From Fig. **??** to Fig. **??**, it is seen that the obtained maximum powers are 114.66 KW(when tilt/azimuth angle is 21?/0?), 61.3 KW(when tilt/azimuth angle is 21?/180?), 95.18 KW(when tilt/azimuth angle is 1?/0?) and 88.23 KW(when tilt/azimuth angle is 90?/0?) respectively considering temperature throughout the day. Again from Fig. **??** to Fig. 12, it is seen that the maximum powers are obtained during 10:00hr to 13:30hr. So from theses simulations it is seen that if azimuth angle is varied from 0? to 180?, 106.48 KW power can be improved keeping tilt angle fixed at 21? and if tilt angle is varied from 1? to 90?, 6.95 KW power can be improved keeping azimuth angle fixed at 0? at the time of 11:30hr. V.

6 Conclusion

The power performance of the Building integrated photovoltaic application is analyzed in the case of Bangladesh climate condition. In the BIPV application the tilt and azimuth angle should be determined very carefully since PV modules are to be oriented at a fixed tilt angle. From the case study it is seen that both tilt and azimuth angle optimization plays a vital role for obtaining the optimal power. rsion I

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Year [1] [2]

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Figure 1: Figure 1 :

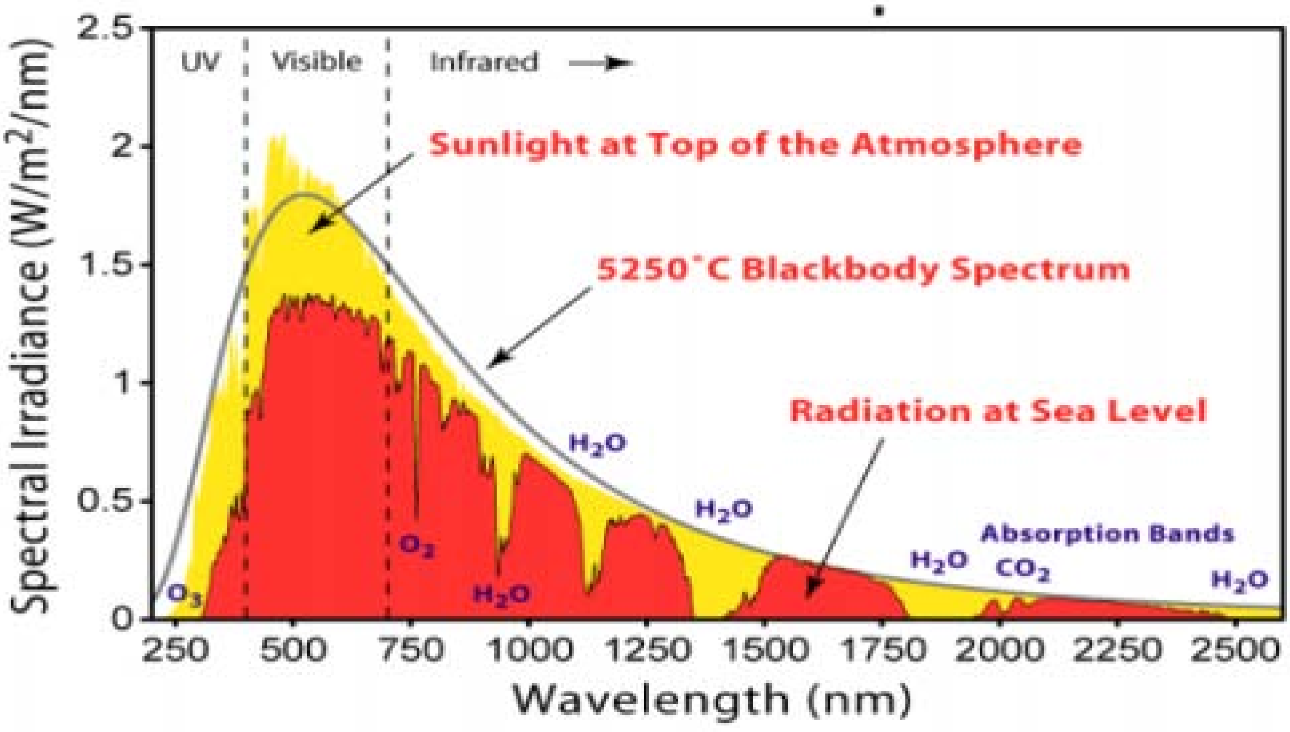

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Figure 2: Figure 2 :

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Figure 3: Figure 3 :

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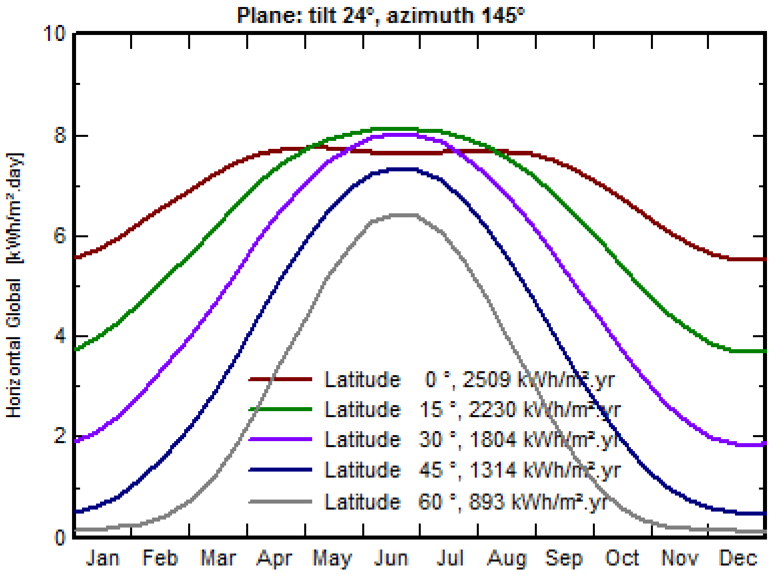

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Figure 4: Figure 4 :

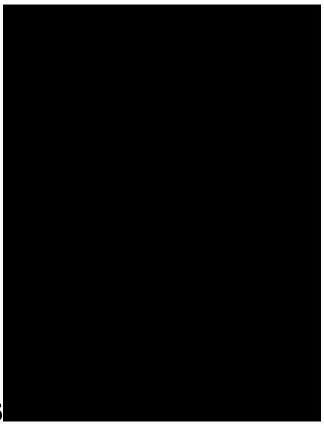
56 

Figure 5: Figure 5 :Figure 6 :

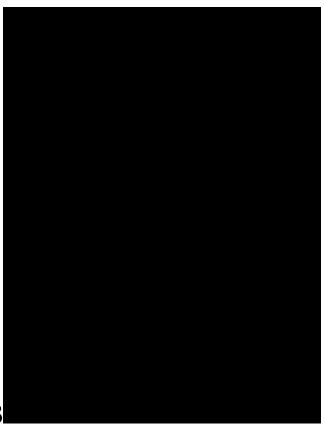
78 

Figure 6: Figure 7 :Figure 8 :

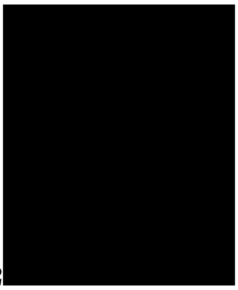
9101112 

Figure 7: Figure 9 :Figure 10 :Figure 11 :Figure 12 :

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	Dhaka City		
Month	Daily mean	Minimum	Maximum
January	8.7	7.5	9.9
February	9.1	7.7	10.7
March	8.8	7.5	10.1
April	8.9	7.2	10.2
May	8.2	5.7	9.7
June	4.9	3.8	7.3
July	5.1	2.6	6.7
August	5.8	4.1	7.1
September	6.0	4.8	8.5
October	7.6	6.5	9.2
November	8.6	7.0	9.9
December	7.55	6.03	9.13

Figure 8: Table 1 :

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