A comparative study for evaluation of power performance of Building Integrated Photovoltaic Application in Bangladesh

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Abstract— *This paper tries to investigate the power performance of the Building Integrated Photovoltaic Application taking comparison for various tilt angle variations keeping azimuth angle fixed considering climate condition of Bangladesh. From the analysis, it is observed that around 4.60% power improvement is occurred at the temperature level of 34°*C when tilt/azimuth angle is varied from 1°/0° to 21°/0° whether it is 3.96% for the tilt/azimuth angle change of 90°/0° to 21°/0°.

Index Terms— Solar irradiation, Temperature, tilt angle, PV system, BIPV application, global radiation, PV power.

I. Introduction

One of the most promising applications of PV power generation is used for residential PV system hooked up to utility grid[1]. The architectural integration of solar PV technology requires an interdisciplinary design approach. This not only imposes collaboration and the presence of highly specialized professionals on the project, but also introduces a sensitivity that goes beyond the building itself, such as social, economic, environmental, energy and ecological issues [3].

Different forms of integration are offered by the various BIPV systems available in France, ranging from classic arrangements of PV modules attached on top of an existing rooftop, to fully-integrated systems, where photovoltaic modules essentially replace building components and thereby provide cover and weather protection in addition to generating electricity. Despite the opportunities presented by fully-integrated systems, this configuration may result in a higher module operating temperature than for openly ventilated PV modules (Fuentes, 1987). This limitation has motivated research efforts to optimise the cooling of PV modules by extracting dissipated heat, and typical BIPV systems include most of the time, an insulated air layer which promotes PV modules cooling by natural ventilation[2].

The power of the Building Integrated Photovoltaic system is greatly affected by temperature and tilt/azimuth angle variation. In this paper the power performance is investigated taking consideration of temperature and tilt angle variation.

II. Solar Irradiance

A measuring station was established at the City University of Hong Kong in 1991. The instruments were installed on the roof-top in a position relatively free from external obstructions and accessible for general inspection and maintenance. Initially, only measurements of global and diffuse solar radiation on a horizontal plane were made. In 1996, the measurement was extended to record vertical global solar radiation on four cardinal surfaces facing the north, east, south, and west [12]. Totally, six pyranometers with an expected error of 3% manufactured and calibrated by Kipp and Zonen, the Netherlands, were used for the solar radiation data measurements. The radiation data were captured simultaneously twice per second and averaged over 10-minute intervals. The specifications for high-quality solar radiation measurements can be found from the guide published by the World Meteorological Organization [13].

The extraterrestrial solar radiation on a horizontal surface Ho is a function only of Latitude and independent of other location parameters. As the solar radiation passes through the earth's atmosphere, it is further modified by processes of scattering and absorption due to the presence of cloud and atmospheric particles. Hence, the daily global solar irradiation incident on a horizontal surface H is very much location specific and less than the extraterrestrial irradiation. The following relation is the generally accepted modified form of the Angstrom-type regression equation, relating the monthly average daily global radiation to the average daily sunshine hours [15]

$$\frac{\bar{H}}{\bar{H}o} = a + b\frac{\bar{S}}{So} \quad (1)$$

Regression Equation (1) has been found to accurately predict global solar radiation in several locations[4-12]. Here $\bar{H}$ is the monthly average daily global radiation on a horizontal surface ($MJm^{-2}day^{-1}$), ($\bar{H}_o$) is the monthly average daily extraterrestrial radiation on a horizontal surface, ($\bar{S}$) is the monthly average daily number of hours of bright sunshine, ($\bar{S}_o$) is the monthly average daily

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maximum number ofhours of possible sunshine (or day length), and a, b are regression constants to be determined.

Advanced research is still in progress to increase the efficiency of photovoltaic cells and optimize the production of energy through minimization of power losses and better utilization of incident solar irradiance [16].The efficiency and proper operation of photovoltaic systems depends on a number of factors. Environmental conditions as well as system design constitute the most important factors in the operation of the PV systems and these can have a significant impact on the efficiency and power quality response of the whole system [17]-[19].

As shown in figure 1, there is a maximum spectral intensity of 0.48 μm wavelength in the green portion of the visible spectrum, in the ultraviolate region (0.40 μm) there is 8.73% energy of the total energy, in the visible region (0.40 μm to 0.70 μm) there is 38.15% and in the infrared region (0.70μm) the remaining 53.12% energy is occupied.

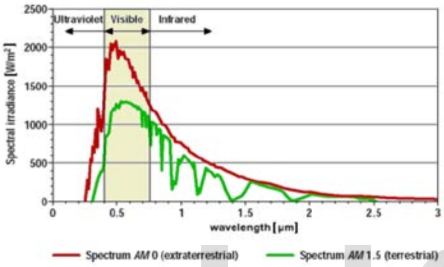

Fig. 1 Extraterrestrial and Terrestrial Spectrum of Sunlight.

III. Characterization of PV Array Taking the Effect of Temperature and Tilt Angle Variation

For characterization of PV system, two PV arrays are taken where each PV array consists of 50 PV strings in parallel connection. Each PV string consists of 20 PV modules (Solarex MSX 64) in series connection. From power data analysis of the PV system, four different types of figures are obtained taking various considerations. From fig. 2, it is seen that at the temperature of 26°C the maximum power obtained is 25.98 KW when tilt/azimuth angle of 21°/0° is considered whether it is 85.41 KW at the temperature of 40°C for the same tilt/azimuth angle. Now from fig. 3, it can be found that the best power percentage is 34.27% at the temperature level of 34°C for the tilt/azimuth angle of 21°/0° in comparison of other two different tilt/azimuth angle. Furthermore from fig. 4, it is observed that around 33.35 KW power can be improved if the temperature is changed from 26°C to 34°C for the tilt/azimuth angle of 21°/0° which is higher than for other tilt/azimuth angle variation. Finally from fig. 5, it is seen that the maximum power incremental rate is 128.89% for the tilt/azimuth angle of 1°/0° at the temperature range of 26°C to 34°C.

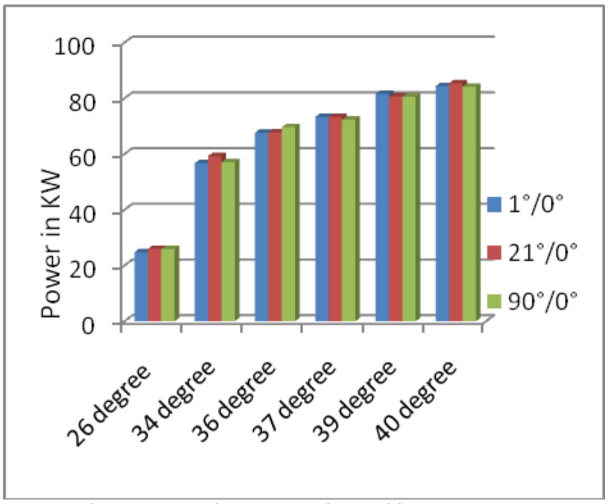

Fig. 2: Power data comparison with temperature

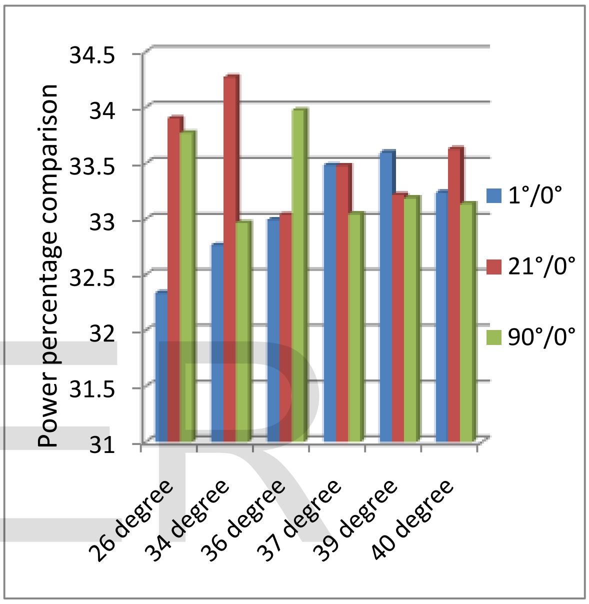

Fig. 3: Comparative Power percentage obtained with temperature

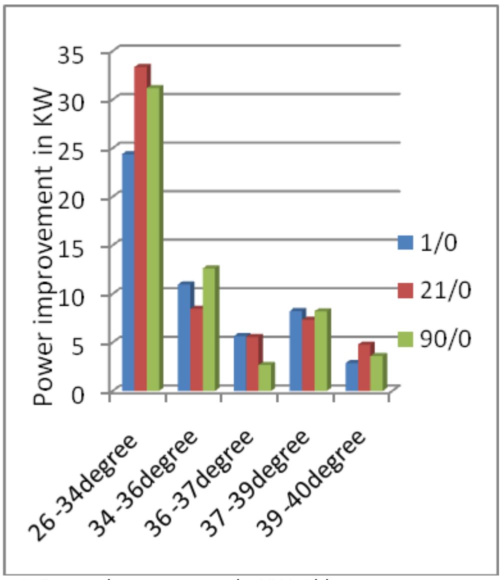

Fig. 4: Power improvement in KW with temperature range.

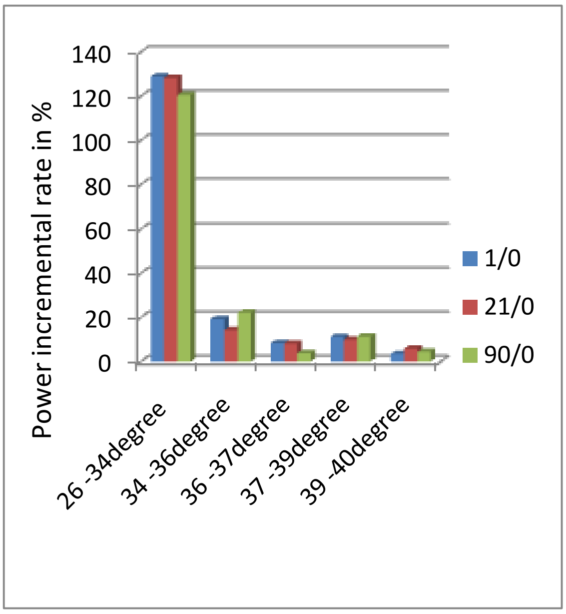

Fig. 5: Power incremental rate in % with temperature range

Conclusion

The power performance of the BIPV is dealt with various parameters. In this paper only temperature and tilt angle issue are taken for the evaluation of power performance. From the observation, it is seen that around 240.68% power can be improved if temperature is changed from 26°C to 40°C for the tilt/azimuth angle of 1°/0° whether it is 228.75% for the tilt/azimuth angle of 21°/0° and 225.19% for the tilt/azimuth angle of 90°/0° for the same temperature change.

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