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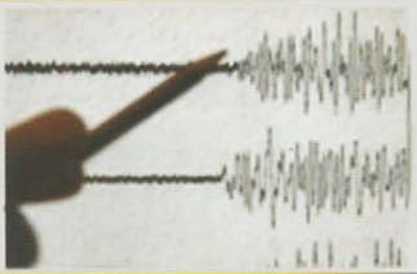
Environmentally Friendly Technology and Disaster Management

Sahid Jaya Solo Hotel - July 14, 2010



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Contents

Evaluation of The Solar Energy Potential for Photovoltaic System in Surabaya

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Abstract—**The energy output from a photovoltaic (PV) system depends on both device characteristics such as efficiency, and surrounding factors where the device is being operated. This paper discusses the aspects related to evaluation and assessment of solar energy potential in a certain location by taking Surabaya as the case of study. The aspects are including solar geometry and position, component of solar radiation, and calculation of amount of solar insulation that can be expected. Results of measurement of global solar radiation in Surabaya (year 2008) shows that global radiation varies from 3.62 – 6,10 kWh/m^2 with an average of 4,92 kWh/m^2. The average of ambient temperature during day time was 32°C. The simulation results shows that, for the fixed panel position, the most effective of azimuth angle is 0° (facing north) with a sloping panel of 15°**

Keywords-component; solar radiation, photovoltaic, solar cell, solar panel, direct radiation, diffuse radiation

I. INTRODUCTION

The energy output from a photovoltaic (PV) system depends on both device characteristics such as efficiency, and surrounding factors where the device is being operated. The surrounding factors determine the solar energy potential at certain location. The main surrounding factors are solar radiation received by the device, ambient temperature, wind speed, and surrounding coefficient reflection. Prior to installing a PV system, it is necessary to evaluate the potential of solar energy at the location where the application system planned to be installed.

This paper discusses the aspects related to evaluation and assessment of solar energy potential in a certain location by taking Surabaya as the case of study. The aspects are including solar geometry and position, component of solar radiation, and calculation of amount of solar insulation that can be expected. The assessment in this paper is emphasized for solar electricity PV application. The measurement data was obtained from local meteorological station. The assessment and simulation were done by using the computer package program PVSYST.

II. ENERGY FROM THE SUN

The sun is hot sphere of gas heated by nuclear fusions reaction at its centre [1]. The spectrum of the radiation from the sun is similar to that of a 5800 K blackbody with fine structure due to absorption in the cool peripheral solar gas. The existence of nearly all life on Earth is fueled by light from the sun. Outside the atmosphere, at the mean solar distance, the beam irradiance, also known as the solar constant (I_0), is 1367 W.m^{-2} [2]. Irradiance is the rate of energy received per unit area, thus the units of irradiance is Watts per square metre (W/m^2), where 1 Watt (W) is equal to 1 Joule (J) per second.

Solar radiation reaches the earth's surface is highly variable caused by absorption and scattering in the earth atmosphere [3]. Solar energy received at the Earth's surface can be separated into two basic components: direct solar energy and diffuse solar energy. Direct solar energy is the energy arriving at the Earth's surface with the Sun's beam. Diffuse solar energy is the result of the atmosphere attenuating, or reducing the magnitude of the Sun's beam. Some of the energy removed from the beam is redirected or scattered towards the ground - the rate at which this energy falls on a unit horizontal surface per second is called the diffuse solar irradiance. The remaining energy from the beam is either scattered back into space, or absorbed by the atmosphere [3]. Global solar irradiance is a measure of the rate of total incoming solar irradiance, both direct and diffuse irradiance, on a horizontal plane at the Earth's surface.

III AVAILABILITY OF SOLAR ENERGY IN SURABAYA

A. Measurement Data

Surabaya is located at 7° 23'03'' South and 112°47'02'' East. Data for monthly solar radiation was obtained from Local meteorological station, Badan Meterologi dan Geofisika (BMG), Surabaya. Tabel 1 Presents monthly average solar radiation on the horizontal plane (in Watt/m^2) in Surabaya for year 2006, 2007, and 2008 respectively. It showed that the radiation is higher during April – Sept. It can be understood that during this period dry season commonly occur in this region. Meanwhile rainy season is during October – March which resulted in the lower average solar radiation. However, recently, the season period is likely unpredictable, and further investigation should be attempted for this as it might be closely related not only to the PV application but also to other issues such as global warming or climate change.

Still from measurement data from BMG it was known that the maximum solar radiation recorded was about 820 Watt/m^2 which is significant lower than solar constant, I_o , as previously mentioned, that means that a large portion of radiation is not reached the earth surface. It might caused by water vapor or other particles in the air and further study is worth while to be made for this case.

TABLE 1. SOLAR RADIATION DATA IN SURABAYA

Month	Average Solar Radiation (W/m^2)		
	2006	2007	2008
Jan	382.3	441.0	411.8
Feb	428.8	338.0	315.0
March	278.5	334.0	354.0
April	424.7	412.0	421.0
Mei	414.5	450.0	440.0
June	439.3	394.0	429.0
July	378.2	472.0	452.0
August	521.4	509.0	480.0
Sep	570.0	523.0	530.0
Oct	584.9	522.0	516.0
Nov	536.7	504.0	404.5
Dec	478.6	393.0	456.8

Source: BMG Surabaya

Results of measurement of global solar radiation in Surabaya shows that global radiation varies from 3.62 – 6,10 kWh/m^2 with an average of 4,92 kWh/m^2. The average of ambient temperature during day time was 32°C.

B. Solar Parameters in Surabaya

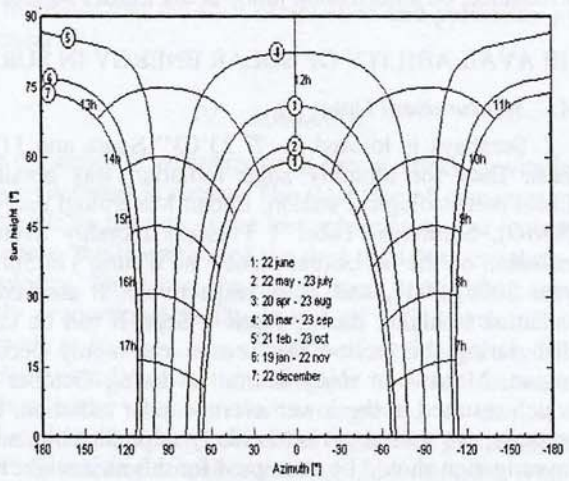

Fig 1. Plan orientation of solar path in Surabaya

Results in this part is obtained by computer simulation using PVSYST. PVSYST is a PC software package for the study, sizing, simulation and data analysis of complete PV systems. The software is oriented towards architects, engineers, and researchers, and holds very helpful tools for education. It includes an extensive contextual Help, which explains in detail the procedures and the models used [4]. The software is available purchased/download at http://www.pvsyst.com.

Solar path for Surabaya, result from simulation, is presented in Figure 1 and Figure 2, respectively for plane and polar orientation.

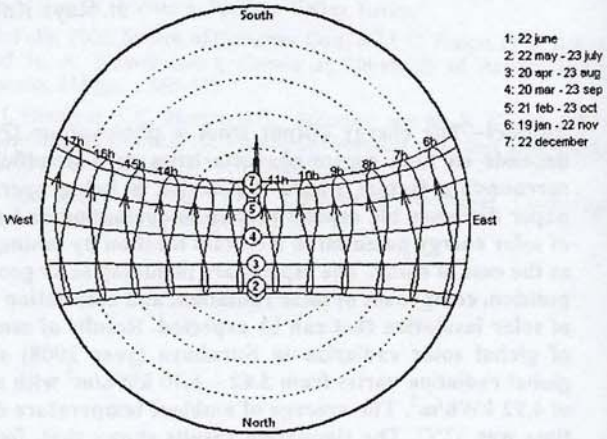

Fig 2. Polar orientation of solar path in Surabaya

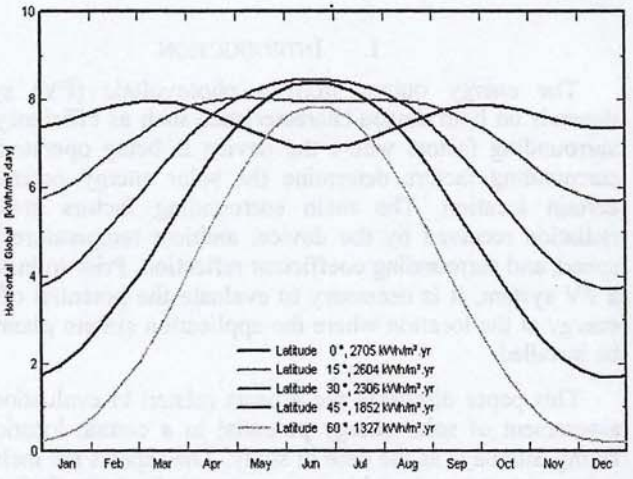

Fig 3. Yearly global Insolation for various latitude (0°,15°, 30° , 45°, 60°)

Orientation and sloping of a PV panel in a particular place should be carefully determined according to the latitude position of the site, in other to optimize the solar inclination which directly related to the output of the PV system. Yearly global solar insolation for various latitude (0°, 15°, 30° , 45° , 60°) for horizontal plane, as result from simulation, is showed I Figure 3. The figure is obtained for clear sky condition.
It can be seen that for the higher latitude the difference is very high between session January and June, on the other hand the variation is slightly for location nearby equator (lower latitude).

As previously stated, Subaraya is located relatively closed to the equator, and variation of solar radiation as showed in Table 1 unlikely caused by latitude position, rather as mentioned above, mostly caused by different season through the year between rainy and dry season.

As Surabaya is located at the south hemisphere, for the fixed azimuth angle of a PV system, the panel should be directed towards north, that is azimuth angle of 0°

Variation of the fixed panel tilt would give significant different results. Figure 4 shows yearly global solar radiation for clear sky in Surabaya for tilted panels of 0°, 15°, 30° respectively.

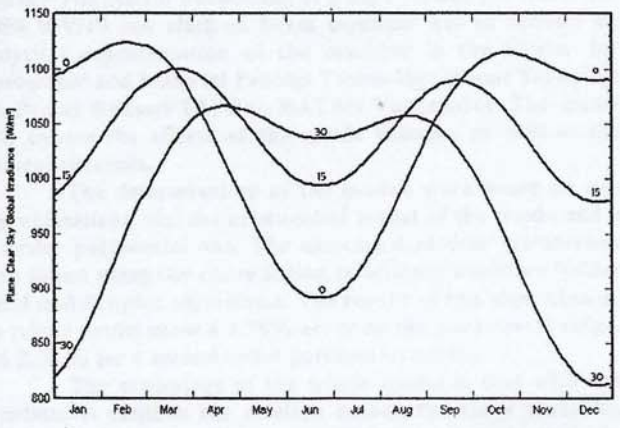

Fig 4. Yearly global solar radiation for various tilt panel (0°,15°, 30°)

Further calculation showed that only very small different total energy output would be resulted from variation fixed tilted range of 0 – 15°. It can also be seen from area below of the each curve from Figure 4, where if the curve is integrated will result in total energy. Hence, for area of Surabaya, it is recommended that a fixed tilted panel is set about 15°C. This is also considering for the external objects such dust or leaves moves away themselves from the panel by the sloping effect, so they would not reduce radiation coming to the panel surface.

III. FURTHER CONSIDERATION

When designing a PV system, it is need to estimate of the insolation expected to panel system. Ussualy, mothly average daily data radiation values, as presented in Table 1, are sufficient [1] and characteristic days near middle of each month are often used to define average monthly values. Besides, portion of direct and diffuse radiation usually need for estimation of the effects of tilted panel, however these need to be estimated from global values if measurement data is not available.

The efficiency of a solar cell depends on many factors. It is therefore possible that a single solar cells performance varies widely depending on its location. Solar panels (a solar panel is an array of solar cells) were until recently almost exclusively used in spacebourne applications. Nowadays, rapid technological advances and a sharply risen public environmental awareness have propelled solar panels to the centre stage in humanity's search for clean energy. The solar industry has exploded, with the photovoltaic industry reporting a combined global revenue of $37 billion over 2008 [5].

Commonly, solar panels are marked by listing their capacity in *watt-peak*. A solar panels power in watt-peak represents its *peak output* under standardized test conditions: 25°C 1.5 airmass, 1 kW/m^2 intensity. However, such conditions might never be reached, as many factors influence the performance of a solar panel Temperature, shading, tilt angle, power conversion loss, soiling and azimuth plane angle.

With increasing temperature, the efficiency of a solar cell *decreases*. This is because a higher temperature increases the conductivity of the semiconductor. This balances out the charge within the material, reducing the magnitude of the electric field at the junction. This in turn inhibits charge separation, which lowers the voltage across the cell. The flow of current to increase slightly as result of increases the mobility of electrons by higher temperature however minor and insignificant compared to the decrease in voltage. The listed power of a solar cell is the power measured under ideal laboratory conditions, which prescribe a temperature of 25 °C. However, on a typical hot sunny day, it is not uncommon for a solar cell to reach a temperature of 70 °C . A general rule of thumb is that the efficiency of a solar cell decreases with 0.5% for every 1 °C above 25 °C . This means that on a hot sunny day, the efficiency of a solar cell could drop as much as 25% [5]. It is therefore extremely important to keep a solar panels well ventilated.

Resistance among of solar cells and their wiring connections within the solar panel directly influences both voltage and current of the panel. Increasing resistance of the panel will cause the voltage-current curve of the solar cell to move away from the so-called *maximum power point* (MPP). At this point, a solar cell produces maximum output ,that is multiplication of current and voltage. Therefore it will give advantageous to maintain this point.

It is important to make sure a solar panel system is as little possible affected by shadows cast by trees, other buildings or other element of the solar panel system. This is because batches of solar cells are connected in series, the entire batch will operate at the current level of *the weakest cell*. By (partly) shading a single cell, one can thus adversely influence the output of all other cells.When installing the system, it must be consider that the angle of the sun changes throughout the year.

IV. CONCLUSSIONS

The energy output from a photovoltaic (PV) system depends on both device characteristics such as efficiency, and surrounding factors where the device is being operated. The surrounding factors determine the solar energy potential at certain location. The main surrounding factors are solar radiation received by the device, ambient temperature, and surrounding coefficient reflection. Prior to installing a PV system, it is necessary to evaluate the potential of solar energy

at the location where the application system planned to be installed. It has been discussed the aspects related to evaluation and assessment of solar energy potential in a certain location by taking Surabaya as the case of study. The aspects are including solar geometry and position, component of solar radiation, and calculation of amount of solar insulation that can be expected. Results of measurement of global solar radiation in Surabaya shows that global radiation varies from 3.62 – 6,10 kWh/m^2 with an average of 4,92 kWh/m^2. The average of ambient temperature during day time was 32°C. The simulation results shows that, for the fixed panel position, the most effective of azimuth angle is 0° (facing north) with a sloping panel of 15°. The panel tilt was counted also by taking into account the possibility of external objects such dust or leaves moves away themselves from the panel by the sloping effect.

REFERENCES

[1] S.R. Wenham, M.A. Green, M.E. Watt, R. Corkish, Applied Photovoltaics, 2nd Edition. Erathscan, 2008.

[2] J. Duffie & A. Beckman (1991), *Solar Engineering of Thermal Process*, 2nd edition, John Wiley and Sons.

[3] http://www.bom.gov.au/sat/glossary.shtml

[4] A. Mermoud, C. Reocker, J. Bonvin (2002), *PVSYST Version 3.21*, Study of photovoltaic system (a computer simulation), University of Geneva – Switzerland

[5] http://www.solarpower2day.net