Surabaya's Solar Radiation Preferences to Design: Building Facade, Solar Hot Water Heater, and Photovoltaic

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Abstract:

The behaviour of solar radiation in Surabaya has many differences to other countries in the tropics, further if it were to sub-tropic zones. The differences are due to each country has its own latitudes, longitudes, and local climatic environmental factors. Surabaya along with its Southern latitude of 7^{o} 17'-21', and Eastern longitude of 112^{o} 47', will have specific solar radiation on horizontal and vertical radiation; even tilted solar radiation surfaces will have greater amount of solar radiation than horizontal and vertical one. The impact of vertical solar radiation that will lead to design carefully any opening on the building facades, building materials, building orientations and building forms in the early design phrase. Founding the optimal orientation and tilted angel for installing solar hot water heater and photovoltaic panels is another crucial factor in order to have the maximum concentration of solar radiation on the panels. Many kinds of glasses use for covering building openings are not only related to viewing purposes but fashions; the curtain glass facades will suffer definitely huge amount of vertical solar radiation for cooling loads in air conditioning and cross-ventilation buildings.

Keywords: solar radiation, building facades, materials, solar hot water, photovoltaic

Introduction

Surabaya city is situated at the latitude 7°17'-21' to the South and at the longitude 112°47' to the East, and has experienced high percentage of sunshine—above 50%--condition throughout the day and the year even during the rainy season in year 2005 (see figure 1). Along with the high sun shine duration, the solar radiation will be impacted highly on any surface like horizontal, tilted staring from 10 percentages to 45 percentages, as well as vertical. Generally speaking, the average solar radiation on horizontal surface will be higher than tilted surface radiation on the latitude of 7 degrees (Surabaya); as Mr. Szokolay said to me at the international conference in Jakarta that the maximum concentrated solar radiation will be on horizontal surface due to the 7° latitude which is closed to the equator. But the truth is the surface with tilted 30-degree angel will have the highest concentrated average solar radiation than other titled angles and horizontal in Surabaya.

These phenomena are only being proved with getting solar radiation researched data on academic environment in the university. Practical designers and product resellers are seldom having those accurate solar radiation behavior data on hand or in the published books in Surabaya. They have been educated mostly with the international architectural books which contain non-local architectural projects built in Indonesia. The International building styles, techniques, and details in the books are often figured buildings that have been built at many different latitudes, longitudes, climates and environment than Indonesia climatic characteristic.

	PERAK 1				JUANDA		
	Temperature (^{o}C)		Sun-shine		Temperature (^{o}C)		Sun-shine
	Max.	Min.	(%)		Max.	Min.	(%)
January	35	24	82		34.8	22.3	45
February	34.6	23.5	70		34.6	21	67.5
March	35.3	23.4	72		34.6	22.7	64.5
April	34.6	24	82		33.1	22.3	69.9
May	35	23.5	86		32.5	22	88.1
June	34.8	24	86		31.8	23.2	77.3
July	34	21.4	86		32.8	19.8	85.2
August	38	21	95		33.2	20.2	95.7
Sept.	36	23	93		34.5	21	93.8
Oct.	37.4	24	74		34.9	21.6	75.9
Nov.	37.4	24.2	71		35	20.1	77.9
Dec.	33.8	23.2	24		34.7	22.2	42.8
Average	**35.2**	**23.3**	**77**		**34**	**21.5**	**41.6**

Figure 1 The Surabaya's Monthly Average Sunshine Duration Percentage and Temperature in 2005 (The Bureau of Meteorology of Surabaya)

Objective

Designers, local architects and foreign consultants as well as product resellers could really understand the behaviour of the Surabaya's solar heat radiations—horizontal and tilted as well as vertical—in order to have maximum solar radiation concentration on solar water heater and photovoltaic applicants, or minimize gaining high concentrated solar radiation on building facades. The propel openings and curtain glasses installed on building facades will have sustainable architecture in term of energy saving domains.

Equipment of the Research

The equipment used to measure the solar heat radiation is silicon pyranometer smart sensors from "HOBO" and Weather Station Data Logger with the specification of the measurement ranging from 0 to 1280 W/m^2. Three pieces of SUNERGY glasses are used for measuring the radiation performances if it were installed on façade buildings. BoxCar Pro4 software is needed.

Solar Radiation Behavior

According to Szokolay, a ray of solar beam emitted from the sun which contained heat radiation to the earth has amount of $173*10^{12}$ KW (173 million million kilowatt) continuous power; the radiation will diminish to the earth because of blocking, reflecting and bouncing by the cloud and many particles in the air. The latitude and longitude of a location in the earth will also affect greatly the concentration of radiation on a surface.

In the city of Surabaya, the concentration of solar radiation impacted on horizontal surface will be much lower than the tilted surface; and the degrees of tilted surface may vary staring from 10^o to 45^o. The lowest concentrated solar radiation is on vertical surface. Yearly an average total amount solar radiation from 6 am to 5 pm (12 hours) in 2006 on horizontal surface is 5,052 W/m^2. Meanwhile, weekly average of daily solar radiation on tilted 15^o North, South, East, and West are 5,255 W/m^2, 4,933 W/m^2, 5,342 W/m^2, and 5,018 W/m^2 respectively. The weekly average of daily solar radiation on tilted 30^o North, South, East, and West are 5,214 W/m^2, 4,516 W/m^2, 5,204 W/m^2, and 4,868 W/m^2 respectively. Now, let us see the daily average total solar radiation on 45^o tilted surface, the amount are 4,336 W/m^2, 3,531 W/m^2, 4,363 W/m^2, and 4,025 W/m^2 respectively. Definitely, Horizontal radiation is greater than tilted 45^o, but it is less with comparing to tilted 15^o, and 30^o.

Figure 2 shows the average monthly solar radiation impacted on horizontal in year of 2006. The horizontal solar radiation remains high even in the rainy seasons, and gradually rises to about 6,000 Watt/m^2 more in dry seasons.

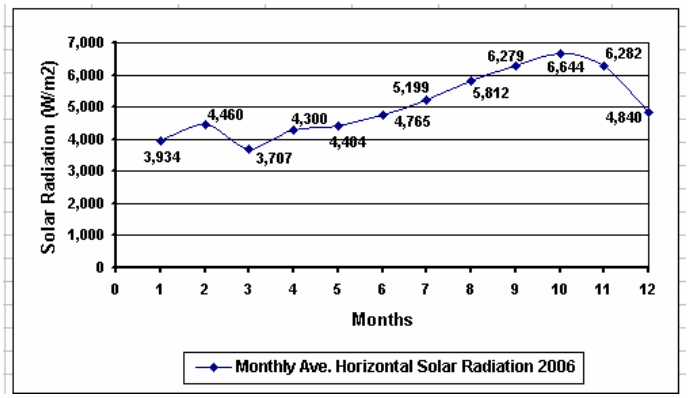


Figure 2 Monthly Average Horizontal Solar Radiations in 2006

Now look at the figure 3, the vertical solar radiation on 4 directions (North, south, east, west) in 2006, the northern hemisphere has the greatest concentration vertical solar radiation following the eastern, western and southern hemisphere. We often feel the western air on evening very hot and dry and try to avoid many openings on west side. With the scientific solar radiation recorded, the western solar radiation concentration is less and ranked third than the eastern side.

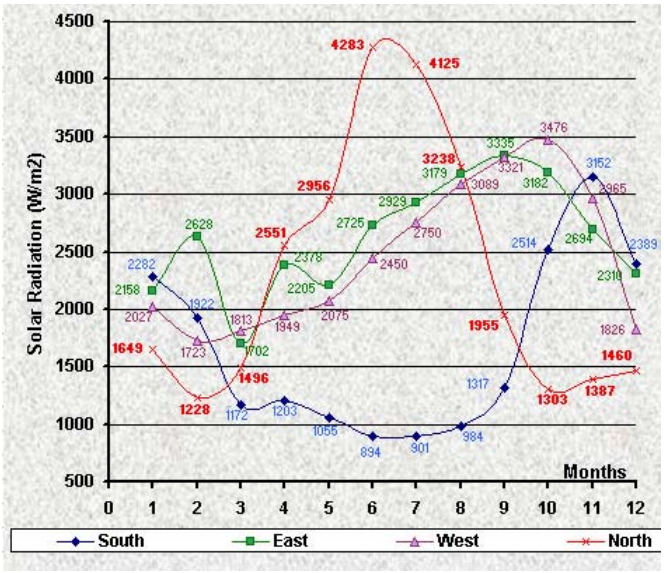


Figure 3 Average Vertical Solar Radiations per year in 2006

There is uncertainty of the greatest solar radiation between tilted angles 15^o to 30^o; therefore, the tilted surface became 15^o, 20^o, 25^o, 30^o (5^o differences). Figure 4 indicates the 20-degree tilted surface has higher concentration solar radiation then other tilted angles.

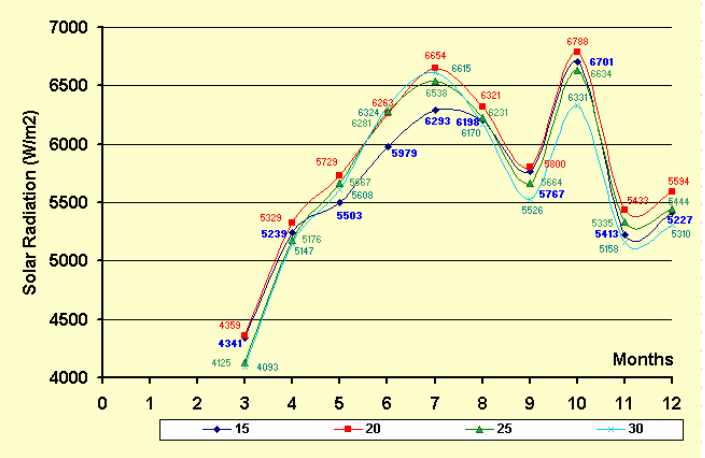


Figure 4 Daily Average Tilted 15^{o}, 20^{o}, 25^{o}, and 30^{o} angles Solar Radiations in 2006

Compare with figure 3, figure 4 has some interesting points. First, although the buildings have been built based on post-modern architectural concepts, they have encountered consideration local aspects for maximum operational building costs and having Surabaya culture identity (Javanese

Building Facades

To have sustainable buildings is to design based on science concept oriented that it considers the needs of energy savings without depleting the energy resource management on Earth's ecological systems.

From figure 5 notes that the vertical solar radiation facing western hemisphere is not as high as northern and eastern side, but the low angle of solar radiation at evening will still have to consider at any opening and curtain glass. Shading devices still definitely needed to block the noon and down solar radiation, meanwhile, northern and eastern façade must have shading louvers and vertical fins to minimize the incoming solar heat radiation. Minimized openings and installed shading devices on northern façade are to be considered as participating in the realm of sustainable architectures.

Two examples of designing building with and without considering sustainability aspects, local climatic factors, and environmental controls have been figured out as modernism icon in Surabaya. Upper figures 5, all modernism buildings built have installed curtain glass which has the most high technology glass invention called "Sunenergy Azur", Stopsol Classic Green, and Stopsol Silverlight Privablue. The three kinds of glasses are supposed to be energy efficient and kindness to the environmental. Unfortunately, the 3 of the high techno-glasses still have higher solar radiation except the Privablue glass.

Lower figure 5, all buildings have been built with the tropical and sustainability concepts. Shading louvers and vertical fins as well as patios have been dominated to form a tropical architecture—responding to the heat sun, heavy rain, and hazy wind.

In figure 6, solar Radiation happened on the Stopsol Silverlight Privablue is the lowest of others. An average hourly of solar radiation is merely 21.33Watt/m^2. With comparing to the Stopsol Classic Green and Sunenergy Azur, the vertical radiation is 44.86 Watt/m^2, and 77.33 Watt/m2. In the meantime, the outside vertical solar radiation happens at the amount of 343.83 Watt/m^2. According to figure 6, the highest solar radiation is at 1 pm.

Figure 5 Modernism and Tropical Buildings existed contradictory in Surabaya

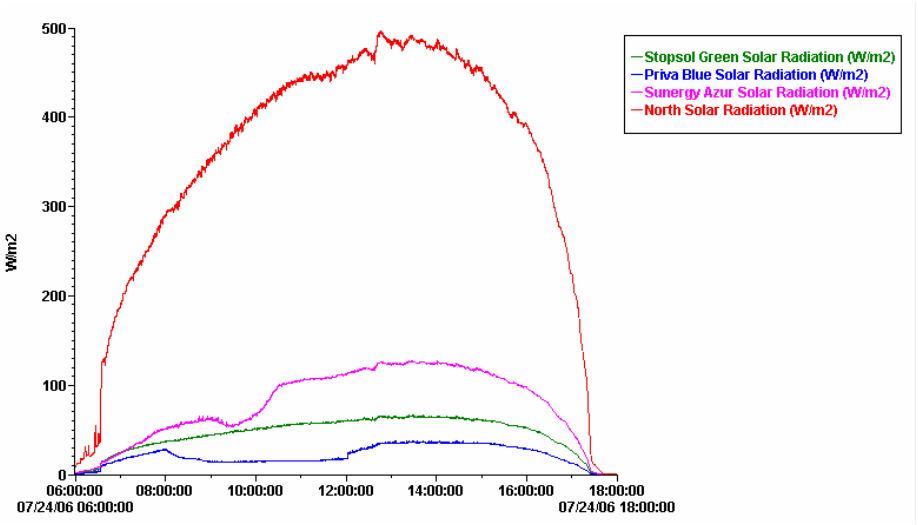


Figure 6 Solar Radiation Performances on 3 curtain glasses in 2006

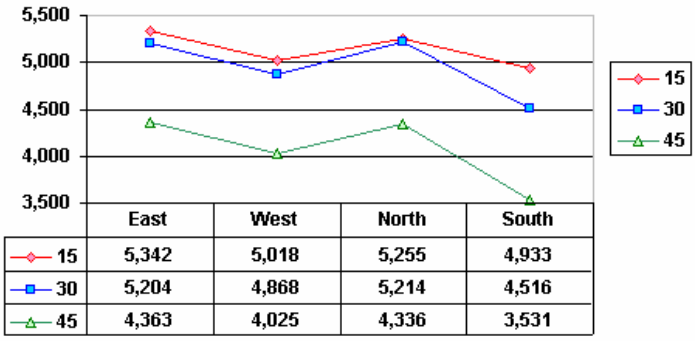
Solar Water Heater and Photovoltaic

The crucial factors installing solar water heater and photovoltaic panels are the tilted angle and orientation. Most of the people do not know well the right orientation, and they just let the hot water heater resellers installed on the roof. Nonetheless solar water heater and photovoltaic resellers has the enough knowledge and environmental factors of Surabaya—optimum angle and orientation. They have the technical skills to install panels rather than scientific knowledge. Let's look at figure 7 (left-side); two adjacent houses both install the solar hot water with different orientations and tilted angles. Each of them has their own confidence that the solar water heater has been installed perfectly, they do not curious at all. Now we observe this house which installed solar hot water heater facing southern hemisphere (also in figure 7 right-side). What happen then? After installing for 2 months, they moved the solar water heater panel to the eastern hemisphere. Well, the eastern hemisphere is better then southern ones. The southern sky has the least concentration solar radiation daily and annually; the southern sky is therefore perfect for installing day-lighting not for solar water heater and photovoltaic in Surabaya, Indonesia.

Other common problems installing solar water heater and photovoltaic are the tilted angles. Most of the solar water heater installed has been mounted base on roof angles. The majority of roofs in

Surabaya has angle greater than 35; even it could be 60 degrees or more. And the minority of solar panels has been mounted independently—mounting on steel frame-works. Figure 8 describes the highly concentration of 15^{o} solar radiation annually with 4 directions orientation. The eastern hemisphere is the best orientation to have optimum total amount of solar radiation of 5,342 Watt/m^{2} per year on tilted 15^{o}. Following the northern side has average of 5,255 Watt/m^{2} per year. But the best orientation is northern hemisphere on 30^{o} tilted angle. Therefore, with regards to figure 3 and 8, the best angle for mounting solar water and photovoltaic panels are 20 degrees with highly recommended orientation to eastern or northern hemisphere.

Figure 7 Nearby Solar Water Heater Mounted (left-side); Changing Installation (right-side)



	East	West	North	South
15	5,342	5,018	5,255	4,933
30	5,204	4,868	5,214	4,516
45	4,363	4,025	4,336	3,531

Figure 8 Weekly Concentration Solar Radiation 15^{o} in 2006 annually

Conclusion

It is clear that there are no official academically recorded the solar radiation behaviour on horizontal, tilted angles especially finding the optimum angle for mounting solar water heater and photovoltaic. The important vertical radiation data are very crucial to early schematically concept designs, massing orientations, and openings as well as curtain glass facades. Professional practice designers, societies, and product resellers have the responsibility to look for the accurate solar radiation data for their environmental works in Surabaya.

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