v. 4, n. 1, 2024

Journal of
Engineering
Research

SOFTWARE FOR THE DETERMINATION AND OPTIMIZATION OF SOLAR IRRADIATION, AS WELL AS THE INSTALLATION OF PHOTOVOLTAIC CELLS IN THE BUILT AREAS OF PUBLIC SCHOOLS TO MAKE THEM SELF-SUSTAINABLE WITH ELECTRICAL ENERGY

Esiquio Martin Gutierrez Armenta
U.A.M Azcapotzalco, Systems Department, computer systems area, San Pablo 420, Colonia Nueva el Rosario, Alcaldía *Azcapotzalco*, código postal 02128, Ciudad de México.

Marco Antonio Gutiérrez Villegas
U.A.M Azcapotzalco, Systems Department, computer systems area, San Pablo 420, Colonia Nueva el Rosario, Alcaldía *Azcapotzalco*, código postal 02128, Ciudad de México.

Israel Isaac Gutiérrez Villegas
Department of Engineering and Social Sciences, ESFM-IPN, Mexico
Computer Systems Engineering Division, TESE- TecNM

Alfonso Jorge Quevedo Martínez
UAM Azcapotzalco, Department of Administration, Area of Mathematics and Systems.
San Pablo 420, Colonia Nueva el Rosario, Alcaldía *Azcapotzalco*, zip code: 02128, ``Ciudad de México``

José Alejandro Reyes Ortiz
U.A.M Azcapotzalco, Systems Department, computer systems area, San Pablo 420, Colonia Nueva el Rosario, Alcaldía *Azcapotzalco*, código postal 02128, Ciudad de México.

Josué Figueroa González
U.A.M Azcapotzalco, Systems Department, computer systems area, San Pablo 420, Colonia Nueva el Rosario, Alcaldía *Azcapotzalco*, código postal 02128, Ciudad de México.

Lourdes Margarita Sánchez Guerrero
U.A.M Azcapotzalco, Systems Department, computer systems area, San Pablo 420, Colonia Nueva el Rosario, Alcaldía *Azcapotzalco*, código postal 02128, Ciudad de México.

Abstract: This article consists of the development of software to determine solar irradiation in the roof areas of public school buildings in order to take advantage of solar energy, convert it into electricity through photovoltaic cells, which will be for the self-consumption and thus allow substantial savings in electric energy fees for public education institutions, and if possible make them self-sustainable. The generation of electric current will only be limited by the available area, the geographical location, also the cost of each panel, the number of photovoltaic panels required can be determined according to the availability of the area. The generationkilo Watt(kW) (represents the amount of power an electrical appliance needs to operate)of the photovoltaic electrical installation. Within the software, the installation is optimized to avoid shadows between panels, determining the minimum distance between them, which must be between 0.5-0.7m. These panels to be used have an approximate generation capacity of 250 Watts of nominal power (Watts or Watts is the unit of power, just as power is the energy that is produced or consumed, this can be thought of as a measure of electrical flow), In an available installation area of 62 meters long so that our case under study can function correctly) this capacity is sufficient for the entire current electrical installation of the campus, whose consumption is approximately 8.3 kW, which includes lighting, computing equipment, using new materials to change solar light to electric, This will reduce the energy consumption provided by the companies. If it were applied, it would be reducing the pollution that causes the greenhouse effect that affects the environment, all living beings, causing respiratory diseases, cancer, and other destructive natural phenomena.

Keywords— Photovoltaic panel, Power, solar eradication, dimensions and electrical generation, Watts, Currents, Kilo watt, kilo

Wat hour

INTRODUCTION

This work has the purpose of obtaining electrical energy that has become indispensable in daily life in all areas such as family and business in almost the entire world, it has become vital in the social and economic growth of any country by Antonio, J., & González, C. (2009). Currently, energy demand has grown very rapidly, having a very strong impact. The use of fossil fuels which pollutes the environment too much, due to this, the search for alternative energy sources has been promoted to satisfy the current needs. These alternative energies are free of gas emissions that are dangerous to health as well as to the environment as stated by Bicaˇ, D., & Cristian, D. (2008). In recent years, technologies have been developed to use alternative energies. It is of utmost importance that changes will continue in the future, improving collection devices by Kativar, AK, & Pandey, CK (2012). Solar energy for the production of electrical energy. Because the sun is an up to now inexhaustible source of radiant energy, which reaches the Earth's surface, it has proven in recent years to be an efficient alternative energy source. This serves us for the production of electricity through photovoltaic devices named by Knox-Hayes, J., Brown, eat. (2013). Photovoltaic systems absorb sunlight for their production, which is why information on solar radiation is essential for its implementation anywhere. However, sun availability at the site of interest depends on the time of day, season of the year, weather conditions, pollution and geographical position of the place according to Soteris, A. (s/f). Solar Energy Engineering: Processes and Systems. A hybrid system is also used for drying food which will be preserved giving good optimal results and is classified in its Tiwari work., G.N. (2002).In recent years, the use of this source has increased from 15% to 25% per year, reported in his work by RAMAJ Ventre, (2010). Performs a detailed performance model for photovoltaic systems Zghal, W., Kantchev, G. eat (2012) presents a modified Voltage Currents relationship for the single diode model. The single diode model has been derived from the well-known equivalent circuit for a single photovoltaic (PV) cell. This semiconductor device that converts sunlight into electricity. The photovoltaic module refers to the number of cells connected in series in a photovoltaic assembly, these are connected in parallel series. The modification presented in this takes into account serial and parallel joins in a matrix. This derivation of the series and parallel relationship gives the current and voltage relationship, this begins with a single solar cell, this article expands on a set of these. In this article, there is a parallel series connection in a matrix that contains the current-voltage relationship modified in the five-parameter model. Therefore, the geometric parameters of variable solar collection will be obtained. Currently, existing parametric models analyze the characteristics of this solar energy and present an estimate of the position of the Sun according to the site of interest. To determine the available solar energy, an evaluation of the electrical energy produced by photovoltaic systems is carried out. These models handle a large amount of information, when executing the calculations necessary to carry out an energy evaluation at a site of interest. The use of computers has made it possible to take advantage of the information processing speed of these devices for the implementation of mathematical models. That is why it is convenient to use Software to obtain the geometric and capacity parameters of a photovoltaic solar system correctly, quickly and efficiently. It was carried out in the C++ compiler, to determine the electrical generation capacity, an area available in particular in public schools. This is not limited, the housing, industrial and agricultural calculation can be carried out, thus taking advantage of available spaces to be able to propose the design of a photovoltaic electrical installation.

A good photovoltaic installation is one that is perfectly sized, which will never encounter electrical supply deficiencies from the photovoltaic panels, as well as the installation accessories. To achieve this, you have to know the energy needs that are necessary for its proper functioning, to carry out the pertinent calculations to obtain the appropriate number of photovoltaic panels necessary for said installation. No installation must ever be placed without having carried out and checked these, if they have not been carried out it will lead to a total failure of the installation.

METHODOLOGY

The roof area of a Martin Oyamburu public primary school, located at Duraznos 426, Azcapotzalco, Pasteros neighborhood, postnatal code 02150 Mexico City, DF, is considered. The available area of the roofs was measured to obtain the geometric parameters, as shown Figure (1) shows that there are only four roofs available that could be used to install a photovoltaic system.

It is possible to determine the electrical generation capacity on each available roof with the area dimensions, with the geometric dimensions of the photovoltaic panels, as well as the maximum power of each solar panel. Figures (2-4) show the technical characteristics, geometric dimensions, of the 250W polycrystalline Phono solar photovoltaic panel used for the optimal design of a photovoltaic electrical installation. The roof area of a Martin Oyamburu public primary school, located at Duraznos 426, Azcapotzalco, Pasteros neighborhood, postnatal code 02150 Mexico City, DF, is considered. The available area of the roofs was measured to obtain the geometric parameters, as shown Figure (1) shows that there are only four roofs available that could be used to install a photovoltaic system. It is possible to determine the electrical generation capacity on each available roof with the area dimensions, the geometric dimensions of the photovoltaic panels as well as the maximum power of each solar panel. Figures (2-4) show the technical characteristics and geometric dimensions of the 250W polycrystalline Phono solar photovoltaic panel used for the optimal design of a photovoltaic electrical installation.

The photovoltaic panel must always be free of any type of shadows so that the maximum electromagnetic radiation reaches it, free of accumulated dust, maintenance must be carried out to obtain the maximum use of the electromagnetic radiation. In order to avoid loss of performance due to shadows produced by rows of panels on subsequent rows, the distance d, measured on the horizontal, between a row of collectors and an obstacle, of height h, that can produce shadows on the installation, The value obtained by Equation (1) will be higher (according to the simplified procedure proposed by the IDEA (Institute for Energy Diversification and Saving) as seen in figure (5). Given by equation (1).

$$d = \frac{h}{Tangent(67^{o} - latitude)} \quad (1)$$

$$k = \frac{1}{Tangente(67^{o} - latitud)} \quad (2)$$

a dimensionless coefficient called k, this value varies with the latitude of the place (table 1), so that the separation between the back of one row of collectors and the beginning of the next will not be less than that obtained by equation (2), applying the height difference between the top of a row of photovoltaic

Journal of Engineering Research ISSN 2764-1317 DOI: https://doi.org/10.22533/at.ed.1317412409019

Figure (1). Geographic location of the public primary school.

Figure (2). Phono solar 250W polycrystalline photovoltaic panel, Solar panels technical sheet, Conermex connects you with the sun

https://www.conermex.com.mx/files/file/HojasTecnicas/01_Modulos/sw-250.pdf.

MECHANICAL CHARACTERISTICS		
Cells	Polycrystalline	156mm x 156mm square 6 x 10 serial parts
Size		1640mm (L) x 992mm (W) x 40mm (H)
Weight		19 kg
Front view		3.2mm tempered glass
Frame		Anodized aluminum alloy
Wire		4mm2(IEC) / 12AWG(UL), 900mm
Connection box		IP 67
PARAMETERS		
Operating temperature		De -40 a +85 ºC
Diameter of a hail ball @80 km/h		until 25 mm
maximum load capacity of the surface		until 5400Pa
fuses in series		15A maximum
IEC Type of application (IEC61730)		A
Fire resistance (UL1703)		C
Maximum system voltage		DC 1000V(IEC) DC 600V(UL)/1000V(ETL)
TYPICAL ELECTRICAL VALUES		
Model		PS250P-20/U
Rated power (Pm)		250W
Rated current (Im)		8.30A
Nominal voltage (Vm)		30.2V
Short circuit (Isc)		8.70A
Open circuit (Voc)		37.8V
Modula efficiency (%)		15.37
TEMPERATURE CHARACTERISTICS		
NOCT (Nominal Operating Cell Temperature)		45°C±2°C
Voltage temperature coefficient		-0.31%/K
Current temperature coefficient		+0.07%/K
Power coefficient		-0.40%/K
WEAK LIGHT		
Intensity [W/m2]	Impp	Vmpp
1000	1.0	1,000
800	0.8	0.996
600	0.6	0.990
400	0.4	0.983
200	0.2	0.952

www.conermex.com.mx info@conermex.com.mx Lada 01-800-363-7441

Figure (3). Solar panels technical sheet, Conermex connects you with the sun, https://www.conermex.com.mx/files/file/HojasTecnicas/01_Modulos/sw-250.pdf

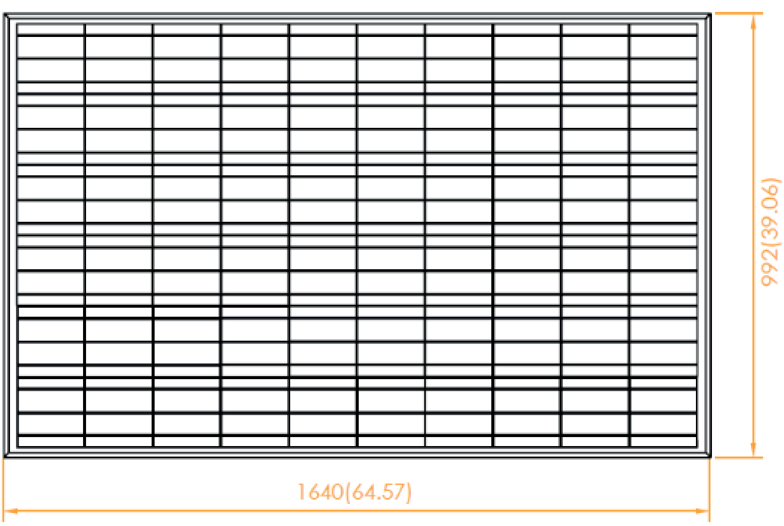

Figure (4). Geometric dimensions of the photovoltaic solar panel

Journal of Engineering Research ISSN 2764-1317 DOI: https://doi.org/10.22533/at.ed.1317412409019

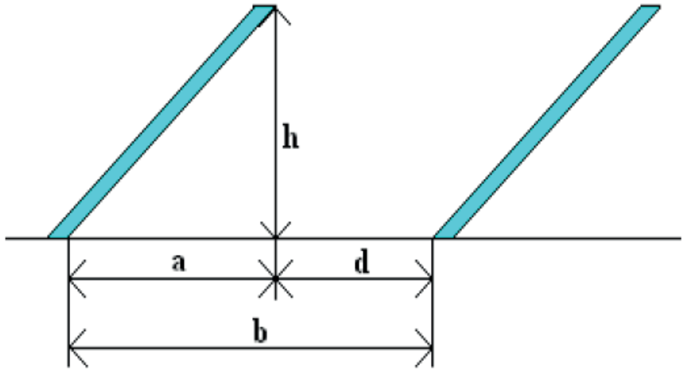

Figure (5). Minimum distance between panels.

Latitud	29º	37º	39º	41º	43º	45º
k	1,600	2,246	2,475	2,747	3,078	3,487

Board (1). k values for different latitudes.

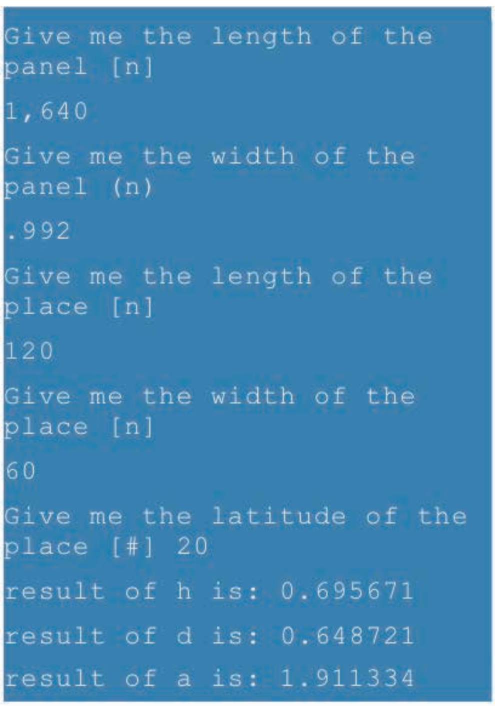

Figure 6. Main Window of the computer program

panels and the bottom is shown in table (1).

For Mexico City, the latitude is 19.24°. For practical purposes, 20° will be used, so the minimum distance between rows of photovoltaic panels to avoid shadows between them is:

With trigonometry according to Figure (5) the dimensions of the photovoltaic panel are calculated.

$$h = L * sine(latitude^{o})(3)$$

Where L is the length of the photovoltaic panel [meters],

*Latitude*is the angle of inclination of the photovoltaic panel given in (degrees [°] or radians)

$$h = (0.992 + 0.05 + 0.992) + seno(20^{o}) = 0.6957 \text{ meters } (3)$$

From equation (1) the minimum distance between rows is obtained

$$d = \frac{0.6957\ m}{tangent(\ 67° - 20°)} = 0.6487 \text{ meters } (4)$$

The separation that these panel arrangements must have will be approximately 65 centimeters.

Figure (6) shows the results of the length and width values of the photovoltaic panel to be used on each of the roofs. The program has a user-computer interface to make it as flexible as possible for its management. Figure (6) shows the main window of the developed program where each of the data to be used is requested.

To determine the number of photovoltaic panels required for this area, their length and width dimensions must be considered, which are provided in table (2) so that the software can calculate them.

Figure (7) shows a run with the Software for the roof 4 where the data obtained from table (2) is observed, the number of panels that could be installed on it, the number of rows and columns can be approximated. with an adequate distribution, thus avoiding the generation of shadows between each row.

With this information, the approximate generation amount of each roof is obtained. As shown in table (3). The kilowatt (kW) or kilowatt is used to measure electrical power, it is also usually called demand, a kilowatt is equivalent to 1000 Watts or Watts, this is obtained by multiplying the voltage by the current.

Watts or Watts is the unit of measurement of electrical power in the International System of Units [SI], which is the production of one Joule per second [1J/s]. They are given this name in English, they can be known as Watts (Watt), this measures the speed at which energy is transformed.

Kilowatt hour (kWh) calculation a solar panel can provide 250 to 400 watts of energy. But it is increasingly common to have them with higher power, for example, 500Watts or a lower capacity for domestic use, such as 150Watts. If a 300 Watt panel is analyzed, for every hour of sunshine it will produce that power. If you have a sunny day like in spring, the serious calculation will be given by equation (5) in our case it would be.

$$Total\ Watts\ X\ number\ of\ hours\ per\ day = Watts(5)$$

Substituting the total values 135 Kilowatt(kW) given in table (3) substituted into equation (5) is obtained.

$$135X5 = 675\ Watts - hour(6)$$
$$136$$

This way, it is obtained that the array produces an amount of 675 kilowatt hours in 5 days in that test case.

RESULTS

In this work, a computer software developed in C++ language was presented,

Roof Number	Long	Broad	Number of panels	Rows	columns
1	62	11.5	280	4	7
2	22.5	eleven	80	4	2
3	21.5	9.2	60	3	2
4	29.7	11.2	120	4	3

Board 2: Shows the measurements of the ceilings and the number of panels to use.

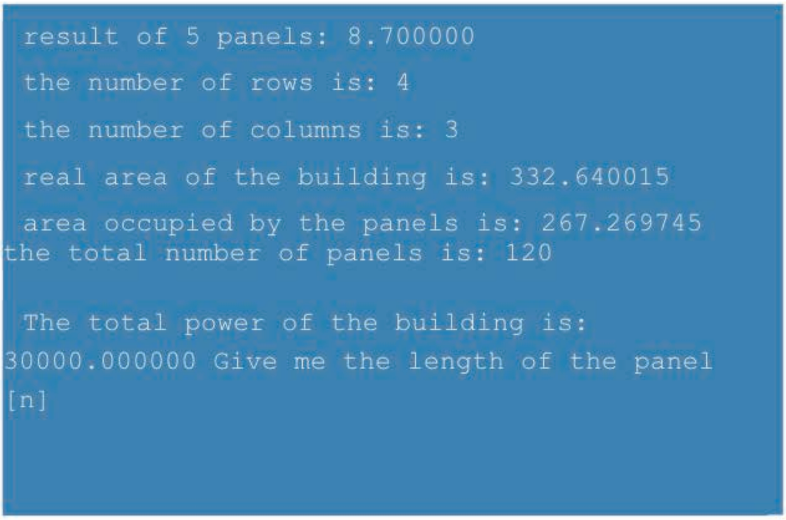

Figure (7). Data obtained with the Roof Software 4.

Ceiling	Row	Column	Kilowatt(kW)
1	4	7	70
2	4	2	twenty
3	4	2	fifteen
4	4	3	30
Total	fifteen	14	135

Board (3). Generation capacity per roof

which allows the sizing of a photovoltaic installation to be carried out quickly and easily, avoiding the production of shadows between rows of photovoltaic solar panels, obtaining their generation capacity individually and completely using the different spaces. (ceilings or available areas). The use of computer software can be extended to know the minimum distance required in a photovoltaic installation with obstacles that produce shadows on it, whether trees, buildings and other high-rise objects.

CONCLUSIONS

The structure of the Software allows you to calculate the sizing of a solar photovoltaic system at a site of interest.

The consumption measured for operation is 8.3 kilowatt provided by the Federal Electricity Commission, with the solar panels there is an approximate value of 135 kilowatt, which gives a performance of this system that is approximately 16.27 times the consumption of interest. This depends on the environmental conditions.

REFERENCES

Antonio, J., & González, C. (2009). Centrales de energías renovables: Generación eléctricas con energías renovables". Bicaˇ, D., & Cristian, D. (2008). Phovoltaic Laboratory for Study of Renewable Solar Energy".

Kativar, A. K., & Pandey, C. K. (2012). A Review of Solar Radiation Models-Part I". Journal of Renewable Energy, 2013.

Knox-Hayes, J., Brown, M. A., Bk, S., & Wang, Y. (2013). Understanding attitudes toward energy security: results of a crossnational survey". Global Environmental Change, 23, 609–622.

Soteris, A. (s/f). Solar Energy Engineering: Processes and Systems.

Tiwari, G. N. (2002). Development and Optimisation of Drying Parameters for Low-Cost Hybrid Solar Dryer Using Response Surface MethodSolar energy.

Ventre, R. A. M. A. J. (2010). Photovoltaic Systems Engineering". CRC Press.

Zghal, W., Kantchev, G., & Kchaou, H. (2012). Determination of the exploitable solar energy for electricity generation using the photovoltaic systems". First International Conference on Renewable Energies and Vehicular Technology, ISBN, 978–979.