

A Comparison Study among Many Methods for Solar PV Plant Design and Sizing for Technical College of Engineering /Mosul

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Received: 27-03-2022, **Accepted:** 04-07-2022, **Published online:** 20-09-2022

Abstract. The use of renewable energy in the recent years has become terribly important, particularly solar PV plants. In this paper, a comparison study was made between the PV *SOL program and the MATLAB simulation program which used to calculate the design procedures for the solar plant laboratory inside Technical College of Engineering /Mosul. A New Zealand method to design and sizing solar PV system, was depended for these calculation, including the environment effect and some factors related with solar system components. The results showed the best design with less components and cost .Finally both programs gave the same design.

Keywords. solar PV system, Design PV system, PV-SOL program, MATLAB simulation.

Introduction

Solar cells are a technology which directly produces electricity when exposed to radiation or light, without environmental pollution or maintenance. The amount of generated current depends on the intensity of the radiation falling on them [1].

These cells are made from two layers of semiconductors, one of which is a silicon with boron called P layer, and the other is a silicon with phosphorus called N layer [2],[3].

These two layers are similar to a diode. The upper layer of the olfactory cell is N layer, while the lower layer is P layer. When exposed to light, solar radiation will move an electron from the P layer to the N layer in one direction releasing a current that travels through the ends of the solar panel [3].

Solar cells connected in series to increase the voltage produced by solar PV, while cells connect parallel to increase the current generated by PV solar to form this connection to the so-called PV

modul, and when they connect to each other, they are called PV panel [4].

when connect the PV panel to each other, you form the string and connect the string, some form the array [5].

Solar PV system.

The Solar System is installed from several elements including the first part and the Solar panels mentioned earlier. The second part is the inverter solar which converts the electrical power (DC) from solar panels to alternating energy (AC) to facilitate the feeding of loads and contains MPPT, which has voltage regulation because it is variable with light intensity. The third part is the batteries that store the electrical power. The final outline of these elements is as in figure 1 [6].

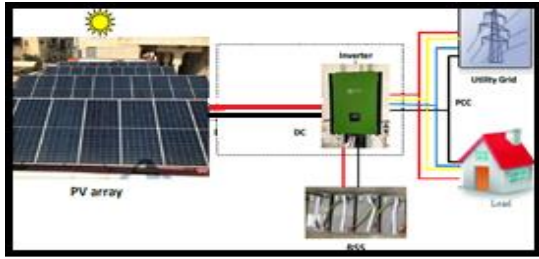


Figure 1. Solar PV system [4].

Block diagram.

The block diagram of solar plant laboratory inside Technical College of Engineering /Mosul is given in figure 2 [7].

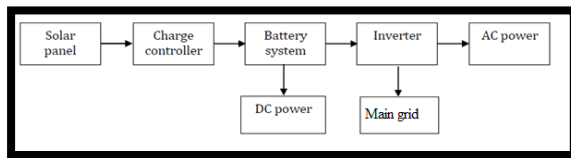


Figure 2. Block diagram of solar panel

Platename of solar PV panel.

The PV panel used in present work was manufactured by (AE Solar GmbH) company which has the specifications listed in table 1.

Table 1 : solar PV panel specifications [6].

Type solar module	PV specification
Power watt	350W
Tolerance	5%
Vmp	38.6V
Vo.c	46.1V
Isc	9.44A
Class	A
Imp	8.94A

Select solar energy lab-consumed loads

Energy meter of the solar plant laboratory inside Technical College of Engineering /Mosul and the reading per month 54.899kWh.

PV sizing.

The New Zealand method was used to calculate the design and sizing data for the laboratory within the Technical College of Engineering /Mosul [8-9].

The consumed load was obtained by.

. Total power load (E_L).

$$E_L = \frac{\text{Power load(AC)}}{\text{inverter Efficiency}}$$

$$= \frac{54.899\text{kWh}}{0.95} = 57.788\text{kWh} \quad (1)$$

. Design power load.

$$\text{Design power load} = \frac{\text{Total power load}}{\text{System voltage}}$$

$$\frac{57.788 * 1000}{48} = 1203.92\text{Ah} \quad (2)$$

. Output capacity array.

$$\text{Output capacity array} = \frac{\text{Design Power Load}}{\text{Battery Efficiency}}$$

$$\frac{1203.92}{0.9385} = 1282.8\text{Ah} \quad (3)$$

. Charge daily of output /panel.

$$\text{Charge daily array} = (1 - \text{tolerance}) * I_{m,p} * F_d * H_t \quad (4)$$

$$\text{Charge daily array} = (1 - 0.05) * 8.94 * 0.95 * 5.99 = 48.3294\text{Ah}$$

. Number of shunt strings(P):

$$\text{Number of shunt strings} = \frac{\text{Output capacity array} * \text{losses factor}}{\text{Charge daily array}} \quad (5)$$

Number of parallel strings =

$$\frac{1282.8 * 1.3}{48.3294} = 34.5\text{PCS}$$

. Number of series modules (S).

$$\text{Number of series modules} = \frac{\text{System voltage}}{\text{Vo.c/panel}} \quad (6)$$

$$= \frac{48}{46.1} = 1.04121 \text{ PCS}$$

. Total modules.

$$\text{Total modules} = (S * P) \quad (7)$$

$$= 34.5 * 1.04121 = 35.9 \approx 36\text{PCS}$$

. Total output PV array capacity.

$$\text{Total output PV array capacity} = \text{Total modules} * \text{Capacity / panel.} \quad (8)$$

$$\text{Total output PV array capacity} = 36 * 350W = 12.6kW.$$

. Battery capacity.

$$\text{Battery capacity} = \frac{\text{Design power load} * \text{No. of autonomy days}}{(\text{DoD}) * \text{Temperature factor}} \quad (9)$$

$$\text{Battery capacity} = \frac{1203.92Ah * 3}{0.8 * 0.95} = 4752.337Ah$$

. Number of string batteries.

$$\text{Number of string batteries} = \frac{\text{System voltage}}{\text{Battery voltage}} \quad (10)$$

$$= \frac{48V}{12V} = 4PCS$$

. Number of shunt batteries.

$$\text{Number of shunt batteries} = \frac{\text{Battery capacity}}{\text{Capacity/battery}} \quad (11)$$

$$\frac{4752.337Ah}{100Ah} = 47.5PCS$$

. Total batteries.

$$\text{Total batteries} = \text{No. of string batteries} * \text{No. of shunt battery} \quad (12)$$

$$\text{Total batteries} = 4 * 47.191 = 188.764PCS$$

. Inverter sizing.

$$\text{Inverter Sizing} = \text{Output array capacity} * \text{Sizing factor.} \quad (13)$$

$$\text{Inverter Sizing} = 12.6kW * 1.1 = 13.735kW$$

. MATLAB simulation

Figure 3 shows the calculation of design data using MATLAB simulation.

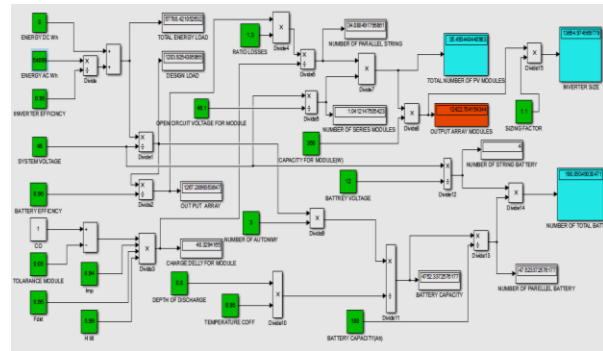


Figure 3 MATLAB simulation to calculate design data.

. PV-SOL program.

All solar panel designs can be designed with a PV-SOL program to give accurate and broadly detailed results. [10-12].

. Total no. of PV modules.

The calculation of the total number of solar panels is shown in the PV-SOL program as in figure 4.

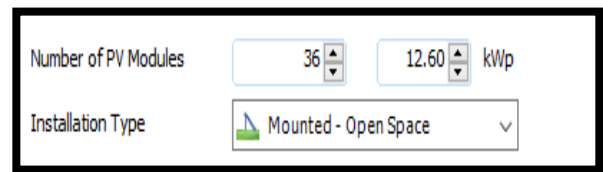


Figure 4. Total PV modules.

. Annual total generated energy .

The expected generated energy of the PV station within a year is shown in figure 5.

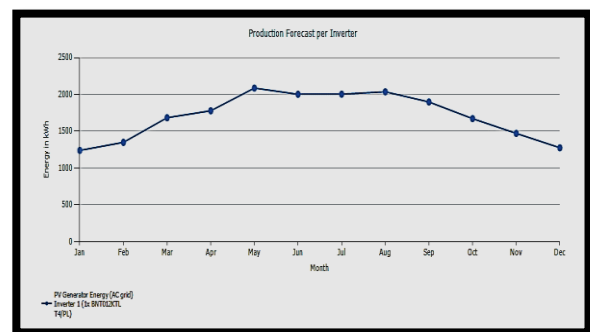


Figure 5. Annual generated energy

. Performance ratio of the inverter.

Figure 6 shows the performance ratio of the inverter during one year.

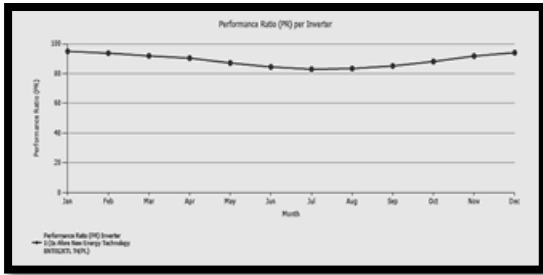


Figure (6) Performance ratio of the inverter

. Temperature modules.

Figure 7 shows the effect of temperature on the surface of the panel and the temperature of the panel itself.

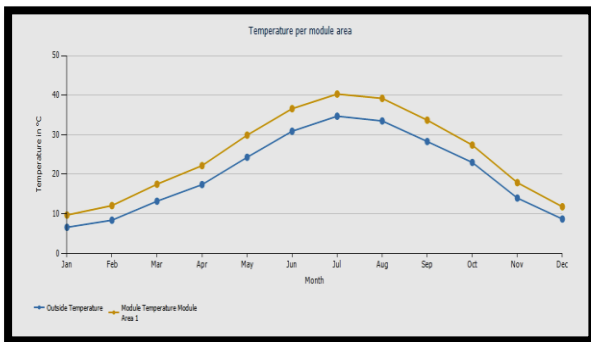


Figure 8. Temperature module

. Irradiance per module.

Figure 9 shows the intensity of solar radiation on the diagonal surface of the panel and horizontal solar radiation.

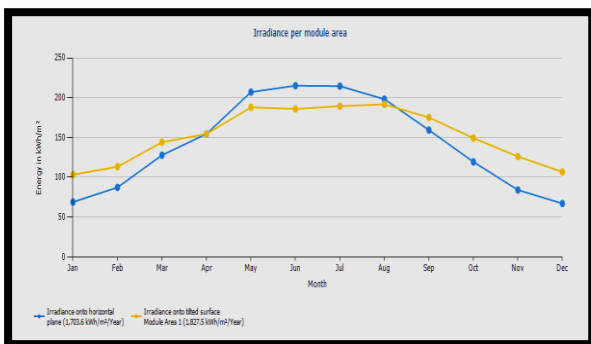


Figure 9 irradiance per module.

. Block diagram.

Figure 10 shows the block diagram of PV system, number of panels, inverter and the load which connected to the main network.

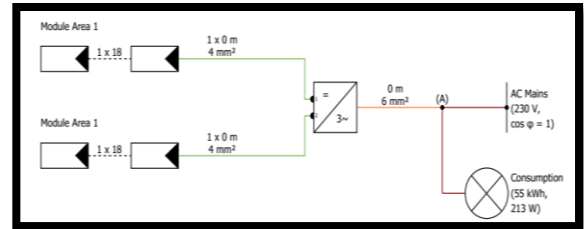


Figure 10 block diagram of the system structure

. Inverter sizing.

Figure 11 shows the size of the inverter and the maximum output capacity from the panels.

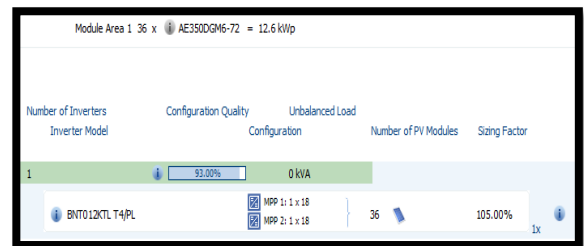


Figure 11 Inverter sizing.

Three dimension drawing.

Figure 12 shows the drawing of solar panels over the laboratory building by drawing three dimensions.



Figure 12 south view 3D picture.

. Simulation results three methods theoretical, PV-SOL program and MATLAB.

In table1 are the three methods for design calculations of solar plant laboratory inside Technical College of engineering /Mosul.

Table3. Items number of solar plant laboratory among three methods.

Data	Theoretical results	PV-SOL program results	MATLAB Simulations results
Total no. of panels	35.6 PCS	36PCS	35.66PCS
Inverter of size	13.735kW	13.23kW	13.735kW
Total energy output	12.6Wh	12.6Wh	12.6

. Conclusions.

From a comparison study among three ways of design. It is concluded that:

- The design data (PV sizing, Battery sizing and inverter sizing) appeared similar by three ways.
- The components of mathematical calculations and software calculations (PV-SOL and MATLAB) programs were giving same components of real solar plant inside Technical College of Engineering/Mosul.
- Solar PV plant inside Technical College of Engineering/Mosul can be studied by the students by simulating this plant according to PV-SOL and MATLAB packages.
- PV-SOL and MATLAB packages gave fast calculations if compared with manual mathematical calculations.
- High reliability of the results obtained by students during laboratory experiments.
- The number of total PV panel are approximately equal for both methods.

References

[1] Mahmood AL. "Design and simulation of stand-alone PV system for electronic and communications engineering department laboratories in Al-Nahrain University". Al-Nahrain University, College of Engineering, Electronic and Communications Engineering Department, Baghdad, Iraq. EAI Endorsed Trans Energy. Belgium: European Alliance for Innovation; 2019 Jun 6; 6:2233–9.

[2] M. Abd and E. Sattar, "Study, Design and Performance Analysis of Grid-Connected Photovoltaic Power Systems Multiprocessor Implementations of Digital Controllers View project", doi: 10.13140/RG.2.2.23240.72961.

[3] Hamoodi SA, Hamoodi AN, Haydar GM. Automated Arrigo Syst based soil moisture using Arduino board. Bulletin of electrical engineering and informatics. Iraq: Northern Technical University (NTU), Engineering Technical College; 2020 June 3. p. 870–6.

[4] D. Vasileska and A. Gerhard Klimeck, "Solar Cells Operation and Modeling."

[5] E. Franklin, "Solar Photovoltaic (PV) System Components," 2018.

[6] B. S. Abdulaziz Molwood Khider Supervisors Asst Fawaz Abdullah Asst Ali N Hamoodi, "Enhancing the Efficiency of Grid-Connected PV System."2021.

[7] A. Tohka, M. Uas, and S. Asplund, " Design and Performance Analysis of a Grid-Connected Photovoltaic System."2017.

[8] A. Romana, E. A. Setiawan, and K. Joyonegoro, "Comparison of Two Calculation Methods for Designing the Solar Electric Power System for Small Islands," in E3S Web of Conferences, Nov. 2018, vol. 67. doi: 10.1051/e3sconf/20186702052.

[9] Ali N.hamoodi ,Fawaz S.Abdulla and sarmad M.sulaiman," Design and sizing of solar cells for the Qayaraha General Hospital and simulated with the PV-SOL program"NTU JOURNAL FOR ENGINEERING AND TECHNOLOGY,2021.

[10] PV*SOL is the 2D solar software design tool for simulating photovoltaic system performance. It is a fully-featured program for those who don't wish to use 3D to model shading and visualise the landscape,2017.

[11] valentin-software.com/en/products/pvsol-premium

[12] V. Baby Shalini, G. Vinay Goud, and C. Radha Charan, "Grid Connected Rooftop Solar Pv System: A Pre-Feasibility Estimation Using Pvsol Premium And System Advisor Model(Sam)," INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH, vol. 8, no. 09, 2019, [Online]. Available: www.ijstr.org