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Design and sizing of solar plant for Qayarah general Hospital and simulation with the PV-SOL program

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Abstract. Solar energy is one of the important renewable energy plants where a solar plant converts the energy produced by the sun into electricity. Now the world is turning to the design solar power plants because they are environmentally friendly and rapid installed and less expensive than other generation plants . In this paper ,design and sizing of solar PV system for Qayarah general Hospital south of Mosul city. A comparison study between mathematical calculations and PV–SOL program was made and the solar system components appeared approximately equally.

Keywords. Solar PV system , solar PV calculation, PV-SOL program, Qayarah loads.

1. Introduction

Solar cells are a technology which transforms light into electrical energy using solar panels, which are composed of several photovoltaic cells. This photovoltaic cell is made of semiconductor matter through which an electrical effort difference is formed when exposed to light and an electrical current is generated. The value of the current depends on the intensity of light or radiation falling on the cell [1]. These panels are mounted from many photovoltaic consists of more than one layer. Most importantly two main layers called the anode pole and the cathode pole.(P, N) where, N represents the silicon layer in which the electrons are , while P represents the silicon in which the holes are holes and the area between P and N is called the transit area and sometimes the shattering front surface of the cell is a transparent layer to increase the intensity of light absorption. The front and rear surfaces have a metal layer of aluminum to form the poles and cover the front surface at 5%, which is only on the side. The back surface covers the entire surface and connects these poles to the load. This can be physically demonstrated when a sufficient amount of light photons or solar radiation is absorbed, some electrons and holes are released from silicon , so that there is a change in kinetic energy [2].When they approach the transit area, the electron and hole pairs are oriented entirely, depending on their charge to the appropriate end of the cell producing a voltage difference on both ends of the cells. Connecting solar cells to each other in series and in parallel is called a modal. And connecting modules to each other in series and in parallel is called a panel. While connecting panels to each other series is called a string [3].

2. Solar PV system

The Solar Cell System consists of components from which PV Solar module, inverter unit, and the charge controller which is mentioned earlier. This system is designed to work with the main network to increase the effectiveness of the main network. Figure 1 represents solar system [4].

Figure 1: Solar system [4].

2.1 Block diagram

The solar cell system can be represented by block diagram to show the connection of the solar cell to the main network. Figure 2 represents the block diagram and that connection is called the (on-grid) [5].

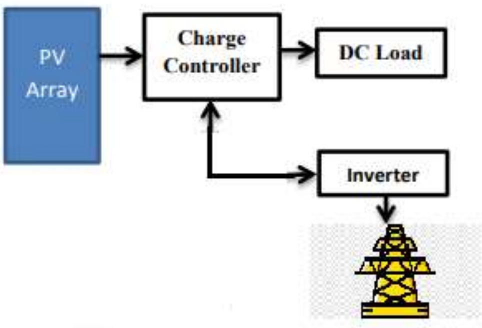

Figure2: Block diagram of on-grid solar PV system

3. A Case study :Qayarah hospital in Iraq

Qayarah is located geographically south of Mosul, Iraq, 36.2 longitude degree and 43.7 latitude degree. The Sun is relatively strong, so the intensity of solar radiation is 1784kWh.m^2 for Qayarah .This means that the solar power systems for these regions will be effectively useful because of the high radiation intensity [5].

4. Main Requirements for the design of a solar cell station

4.1 PV Solar module

Solar module works by particles of light allowing photons to knock electrons free from atoms to generating electricity. Figure3 represents the solar PV module [3].

Figure 3: PV solar module [5]

4.2 Inverter unit

It is used to convert the energy produced by the photovoltaic cell from DC into an alternating voltage for easy feeding loads [5]. MPPT is the controller built in the inverter used to regulate the voltage from a photovoltaic cell because it is variable with the intensity of the light or the radiation falling on it [6]. Figure 4 represents inverter unit.

Figure 4: Inverter unit [7]

4.3 Battery

The Battery is used to store electricity when there is light and then feed the system in the absence of light [8] .Battery bank can be used if the national grid current is not continuous [9]. Figure 5 represents battery unit.

Figure 5: Battery unit [10]

5. Project localization

This project is located in Iraq, south of Mosul, is a hospital where the need for continuing electricity is mandatory to keep oxygen in operation to save the lives of Covid 19 patients and also the people with respiratory problems.

6.Select name plate for PV solar

Table 1 represents the solar PV module specification [11].

Type solar module	PV Sol Company
Power solar	200W
Tolerance	3%
Vmp	18.2V
Vo.c	22.0V
Isc	12.12A
Class	A
Imp	10.99A

7.Select hospital-consumed loads

An inventory of the instruments to be run on the solar power plant, the number of hours to run per device, the capacity of each device in watts, and the total energy needed have been specified clearly in table2 [12-14].

Table 2. Qayarah loads in (kWh)

Item	Name device	No. of device	Power W	Hour operation	Energy kWh
1	Oxygen device	10	550	9	49.5
2	Cooling devices	3	1750	4	21
3	Ceiling fan	6	200	4	4.8
4	Lighting led	20	10	9	1.8
5	Water fridge	4	475	2	3.8
6	Heater	4	400	3	4.8
		Total			85.7

8. PV sizing

The first step, all the electrical devices available at the residence itemized according to the power ratings and time of operation per day .The total consumption of energy is used to calculate PV system sizing.

8.1Calculate the total energy production of hospital loads during cloudy days

cloudy day x total load energy ...(1)

$$4\text{x } 85.7\text{KWh} = 342.8 \text{ Kwh}$$

- Total load current

$$= \frac{load\ energy}{220} \quad \dots(2)$$

$$= \frac{342.8\text{KWh}}{220V} = 389.5454\ Ah$$

- Total current load during cloudy current

cloudy days x total load current ...(3)

$$4 \text{ x } 389.5454 = 1558.1818 \text{ Ah}$$

- Total load current without and with wiring efficiency

$$= \frac{\text{load current}}{\text{wire eff x DoD}} \quad \dots(4)$$

$$= \frac{389.5454}{0.9 \text{ x } 0.8} = 541\ Ah$$

- Last current

$$= \frac{\text{load current without inv eff}}{\text{wiring eff}} \quad \dots(5)$$

$$\frac{541Ah}{0.95} = 569.51Ah$$

- Last energy

last current x 220V ...(6)

$$= 569.51 \text{ x } 220 = 125292.38 \text{ Wh}$$

- Last energy with sunlight

$$= \frac{last\ energy}{sunlight} \quad \dots(7)$$

$$\frac{125292.338}{5.99} = 20916.924 \text{ Wh}$$

- Total modules

$$= \frac{\text{last energy}}{\text{power panel}} \quad \dots(8)$$

$$= \frac{20916.924}{200w} = 104.8 \text{ modul}$$

- Total PV array cap

No. of PV *PV panel power ...(9)

$$= 105 \text{ x } 200 = 21\text{KW}$$

9. Battery sizing.

The amount of rough energy storage required is equal to the multiplication of number of autonomy days and power demand.

- capacity battery

$$= \frac{\text{last energy x day of cloudy}}{48V} \quad \dots(10)$$

$$= \frac{20916.924\text{Wh x } 4}{48\text{V}} = 1743.077\text{Ah}$$

- Battery chain number

$$= \frac{\text{Base system voltage}}{\text{Battery voltage}} \qquad \ldots(11)$$

$$= \frac{48}{12} = 4\ pieces$$

- No .of shunt battery

$$= \frac{\text{Total capacity}}{\text{Ah battery}} \qquad \ldots(12)$$

$$= \frac{1743.077Ah}{256\text{Ah}} = 7pieces$$

- Total of battery

chain number X shunt number ... (13)
4 pieces x 7 pieces =28 battery

10.Inverter sizing

When sizing the inverter,the actual power drawn from the devices that will run at the same time should be calculated as a first step.

=Max load x oversupply co factor ... (14)
=21.4 x 2 =42.8KW

11. PV-SOL program results

All types of PV system can be designed and simulated based on PV–SOL program. This program supports the users with numerous tools for small system large size .Also supports 3D visualization [15-17].

- Total no .of PV module
  The total number of PV modules was calculated according to PV–SOL program as shown in figure 6.

Figure 6: PV modules number

- Total energy per year
  The annual total energy is shown in figure 7.

Figure 7: Annual total energy

- Circuit diagram
  The final circuit diagram that obtained by PV-SOL is given in figure 8.

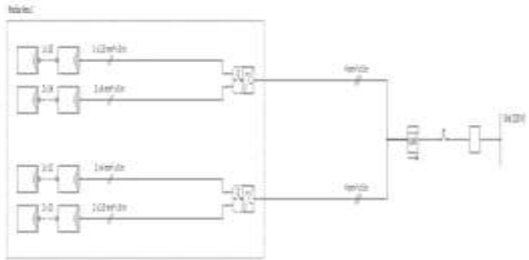

Figure 8:PV-SOL circuitdiagram of designed system

- The relationship between annual rate and energy is shown in figure 9.

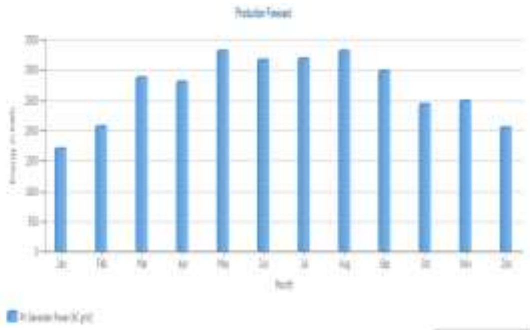

Figure 9: Chart of annual rate with respect to energy

- Figure 10 represents the energy production forcasting per inverter.

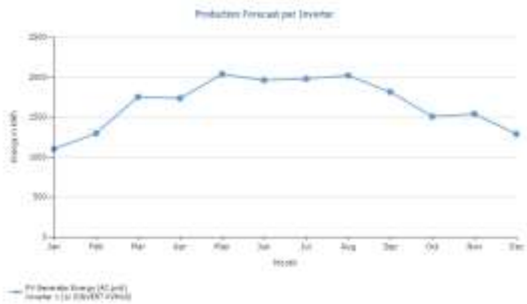

Figure10: Energy production per inverter

- The relationship between energy production per month at irradiance on to horizontal and irrodiance onto tilted surface is shown in figure11.

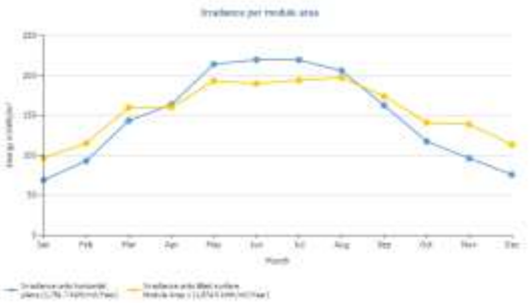

Figure11: Irradiance effect on energy per month

- Figure 12 represents the temperature distribution per month for both outside temperatue and module temperature.

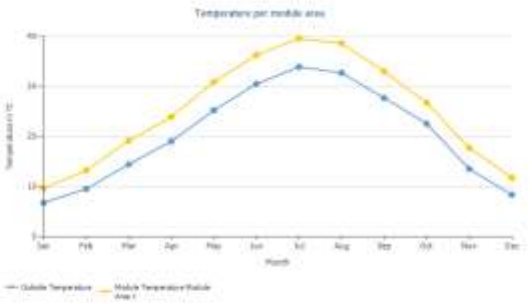

Figure12: Temperature distribution per month

12. Comparison between theoretical and PV-Sol program results.

The number of solar PV system components according to theoretical and PV-SOL program are listed in Table 3.

Table3. Theoretical and PV-SOL program results (on-grid)

Information	The theoretical results	The PV-Sol program results
Total no. of modules	104.8 pieces	105 pieces
Inverter of size	42.8KW	45KW
Total energy hospital	85.7KWh	88KWh

13. Conclusions

- PV system is very important for Hospital sites especially during operations.
- The maintenance of PV system is very simple as compared with traditional plants.
- The number of PV system components are approximately equal for both methods.
- PV-SOL program has given fast calculations as copmared with mathmatical way.

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