PV Solar Systems Affecting Conditions and Solutions

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***Abstract* — The evolution in the field of solar energy is progressing at an accelerating pace. This paper presents a study of conditions that affects the power generation on PV solar systems with a results by a Matlab®/Simulink® simulation. Some new technologies and techniques used as a solutions well be suggested and discussed. Hybrid Bifacial PV thermal solar panels is a promising mature technology that will enhancing visions for entrepreneurial projects.**

Keywords—Solar; Partial shading; Effeciency; Cooling.

I. INTRODUCTION

Most countries' electricity production is provided by fossil fuels such as coal, oil, and gas, but their availability is limited. The conversion of energy stored in fossil fuels into useful forms causes damaging pollutants that leads to global warming, which is one of the major threats for the entire world.

The world is moving toward renewable energy. As a result, research in this area has increased and solar energy has become the most widely used source of energy [1]. In photovoltaic solar technology a panel consisting of many solar cells connected to each other in series and parallel is used. A solar cell is a semiconductor device that directly converts the energy from sunlight into electrical energy through the process of photovoltaic. Solar energy obtained from a solar PV cell is not constant all the time, because the conversion system have some general problems, such as dust and surface operating temperature which can negatively affect the efficiency of the conversion system [2].

II. CONDITIONS AFFECTS THE EFFICIENCY OF SOLAR SYSTEMS

A solar cell is a semiconductor device that converts solar energy directly into electrical energy via the photovoltaic process. The photovoltaic cell (solar cell) converts only a small fraction of the irradiance (~ less than 20%) into electrical energy which is then transformed into heating of the cell. Two of the important parameters that affects the energy output of the PV module or the system are the Partial Shading Condition (PSC) and the Surface Operating Temperature.

A. Partial Shading Condition (PSC)

Partial shading condition of solar panels or systems could happens due to manufacturing errors or dust gathering.

PSC causes significant reduction in the system power output, which may lead to: Hotspots and Junction diode failure. P-V characteristics, under uniform solar irradiance level with no shading have one optimal operating point corresponding to a unique maximum power point (MPP).Because shading on one cell in a module, the P-V characteristics of solar panels becomes very complicated as multiple maximum power points exist on it [3]. Comprehensive research on dust deposition have been conducted since 1990, with enhanced experimental measurement accuracy. After a short exposure time, they discovered that many collectors had lower electrical and thermal outputs [4,5]. In Saudi Arabia, ElShobokshy and Hussein were pioneers in conducting a detailed analysis on the effect of dust on PV cells [6]. Physical properties of dust aggregation and deposition density on PV performance were investigated. The effect of cement particles was found to be the most important, with a deposition of 73 g/m2 cement dust resulting in an 80% reduction in PV short circuit voltage [6].

A Matlab®/Simulink® simulation result shown on Figure.1 for a model of 5 strings PV array was done to simulate P-V characteristics When four stings from the array are shaded with irradiance of 0.2kW / m2, 0.4kW / m2, 0.6kW / m2, and 0.8kW / m2, respectively.

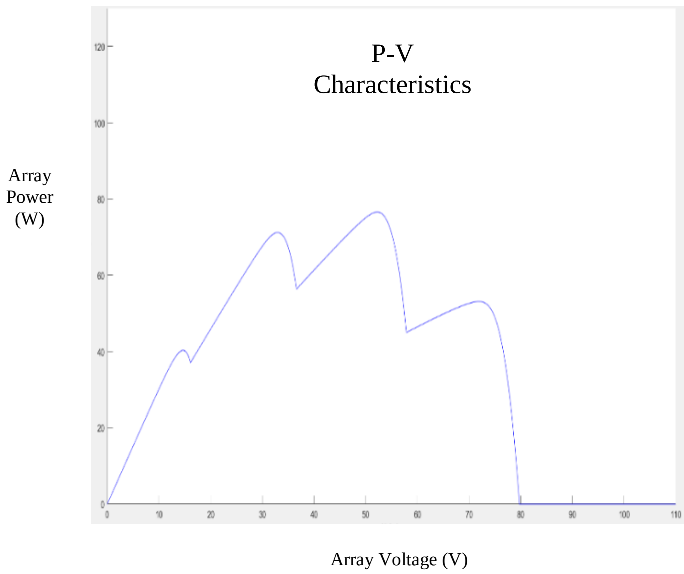

Fig.1. P-V characteristics *simulation results when 4 strings from one array are shaded under PSC*

B. *Surface Operating Temperature*

Due to some degradation factors, PV panels usually have a poor conversion quality. When forecasting energy output, the temperature of PV panels is considered a critical factor. Long-term high-temperature working conditions, for example, can result in irreversible deterioration of a PV panel's electric output capacity. The high temperature is caused by waste heat produced by solar irradiance absorption. Just about 20% of the incident solar energy is converted to electricity when it hits a PV panel [7]. The majority of the remaining material is converted to gas. As a result, the accumulated heat energy raises the operating temperature of the PV plate, lowering its electrical efficiency. For each degree of temperature increase under standard test condition, the PV panel's conversion efficiency drops by around 0.40 - 0.50 percent [8]. However, since the real sun conditions are dependent on the complex climatic conditions of each region, all data rarely match the real sun conditions.

The temperature coefficients of the Voc, Pmax, and fill factor (FF) are all negative, while the Isc is positive [9]. P.K. Dash and N.C. Gupta [10] studied the influence of temperature on the output power of various types of PV panels. Monocrystalline PV panels had the highest output power losses, with an average of -0.446 percent /°C, according to the temperature coefficient of PV panels.

A Matlab®/Simulink® simulation result shown on Figure.2 for a model of 5 strings PV array was done to simulate P-V characteristics when varying the ambient temperature of 0, 25, 35, and 50 °C, respectively. By irradiance of 1.0kW / m2.

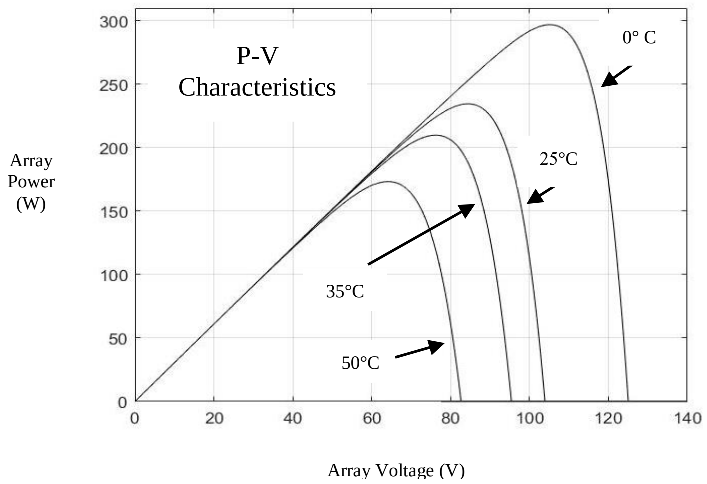

Fig.2. P-V characteristics *simulation results of PV array at various temperatures*

III. Technologies Suggested and Used to Increase the Efficiency of PV Systems

As mentioned on the previous section, temperature fluctuations affects photovoltaic (PV) cells. The operating temperature of the PV cells increases linearly as the ambient temperature and the intensity of solar irradiance falling on the PV cells increases. This increase in PV cell operating temperature and Dust gathering leads to reduction in open circuit voltage, fill factor and power output from Monocrystalline and Polycrystalline PV cells, which are utilized in the majority of PV applications.

Three technologies of the suggested and used to improve the efficiency of solar system would be discussed on this section, as follow:

A. *Hybrid Bifacial PV Thermal solar panel*

Bifacial PV is a promising mature technology that increases the production of electricity per square meter of PV module through the use of light absorption by generating power from the both faces [11], once this technology is modified with a liquid pipes are placed through the two front and rear solar cells faces as shown on Figure.3 to be used as an integrated system of complete cycle cooling and heating at the same time as shown on Figure.4

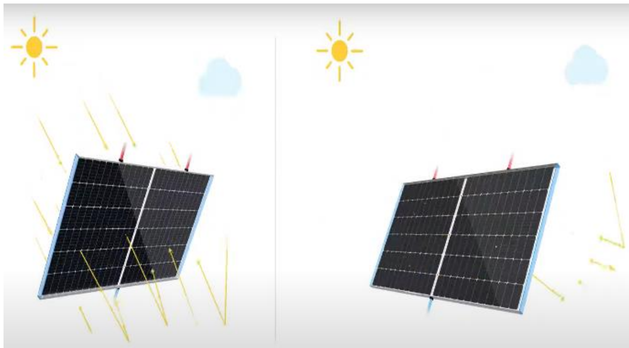

Fig.3. Bifacial PV Thermal Solar Panel.

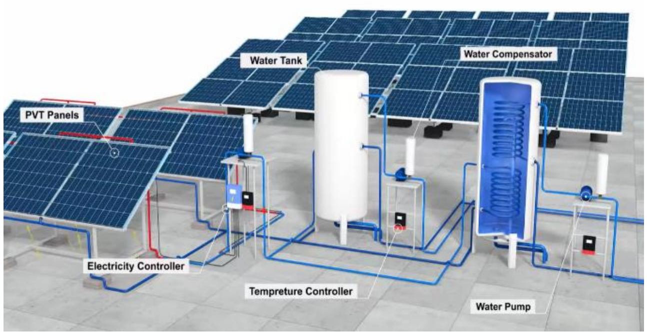

Fig.4. Integrated system of generating electrical and heat powers.

This technology can be used on small and medium buildings, providing these facilities with an electricity and hot water used on several ways like, central heating system. Also, this technology have many advantages, such as:

- More generated power, because of generating electricity and absorbing heat from both faces.
- No hotspots, where this technology acts uniformly with fast cooling system.
- Higher efficiency.

B. Using of different PV array configurations

There is a group of array configurations that helps reduce Power losses in case of partial shading according to O.Bingöl and B.Özkaya [12].

Array configurations:

- S configurations all modules in series, as shown in Figure.5 (a).
- SP all modules are first connected in series form and then these series connection are connected in parallel, as shown in Figure.5 (b).
- TCT It is derived from SP configuration by connected crossties across each row of the modules, as shown in Figure.5 (c).
- BL There is a bridged unit with four modules. Two modules in a bridge are connected in series and then they are connected in parallel, as shown in Figure.5 (d).
- HC is a modified version of BL configuration and its bridge size is variable, as shown in Figure.5 (e).

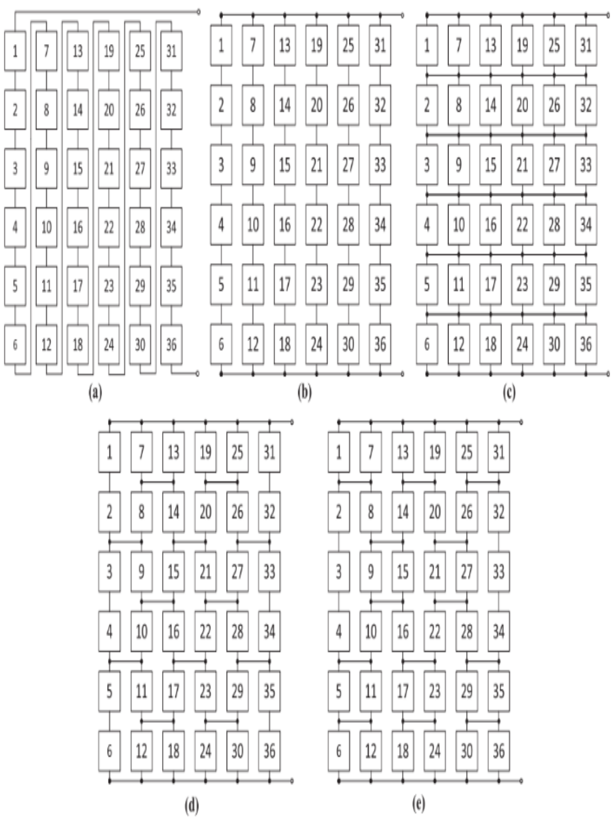

Fig.5. The schematic diagram of PV array configurations (a) S, (b) SP, (c) TCT, (d) BL, (e) HC [12].

After applying different instances of partial shading to all array configurations as shown on Figure.6, the results on Table.1 showed that TCT configuration was the best in reducing power losses.

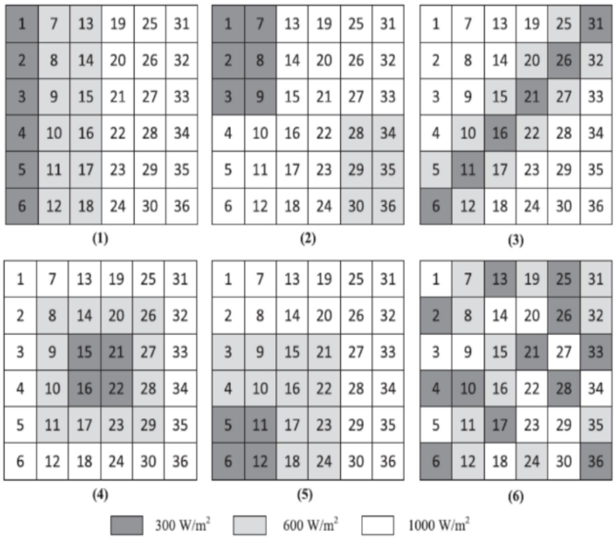

Fig.6. Partial shading (a) Case 1, (b) Case 2, (c) Case 3, (d) Case 4, (e) Case 5, (f) Case 6 [12].

Table 1

Simulation results under shading cases. The bold values show the maximum values [12].

	Configuration	P_{max} (W)	V_{max} (V)	I_{max} (A)
Case 1	S	941.3655	530.1	1.776
	SP	**1242**	**97.5**	**12.74**
	TCT	**1242**	**97.5**	**12.74**
	BL	**1242**	**97.5**	**12.74**
	HC	**1242**	**97.5**	**12.74**
Case 2	S	1128	401.3	2.811
	SP	1112.2	102.3	10.87
	TCT	**1340.4**	**99.61**	**13.46**
	BL	1176.8	106	11.09
	HC	1164.1	105.01	11.07
Case 3	S	555.1542	633.2	0.877
	SP	725.748	87.75	8.271
	TCT	**898.2565**	**100.3**	**8.954**
	BL	734.5931	85.3	8.612
	HC	774.7161	101.3	7.645
Case 4	S	1015.2	573.9	1.765
	SP	1103.4	104.6	10.55
	TCT	**1163.2**	**104.3**	**11.15**
	BL	1106.8	103.9	10.65
	HC	1134	103.7	10.93
Case 5	S	1005.8	566.8	1.774
	SP	1096.2	103.7	10.57
	TCT	**1159.3**	**104.3**	**11.12**
	BL	1116.1	104.5	10.68
	HC	1102.3	103.6	10.64
Case 6	S	729.9984	415.5	1.759
	SP	682.9867	48.96	13.95
	TCT	**1002.2**	**101.3**	**9.885**
	BL	732.2328	103.9	7.045
	HC	742.4291	104.5	7.105

C. *Selection of solar PV plant location*

Choosing the PV plant site before starting of implantation plays a major role and has it is impact on project's yield during the operational period.

Based on our experience on managing an operational and maintenance contract of two PV plants, we noticed that the location of the PV project and the surrounding area are very important. By comparing the location of both sites
Through aerial photos taken by Google Earth®.

Plant No.1 shown on Figure.7 is a 1.1 Megawatts (MW) located on a dry area surrounded by quarries, plant No.2 shown on Figure.8 is a 1.6 MW located on wet area surrounded by farms.

PV plant No.1 has a big issue on generating the monthly target of power yield, especially during summer, which means, more cleaning rounds per month need to done.
Compared with PV plant No.2, the dust adhesion coefficient is relatively large on PV plant No.1. So, a comprehensive study of PV plant location is very important.

Encouraging tree planting on the surrounding area of PV plant promotes the concept of green energy, with taking into account the shade formed by plantings during the day. And it is important to mention that one planted tree doing very much, like:

- Absorbs about 20 kg of dust per year.
- Helps cool down the surrounding area up to 4 degrees.
- Produces 700 kg of oxygen per year.
- Absorbs 20 tons of carbon dioxide per year.

Also, if the PV panels' installation location is seaboard, this system can be used more effectively [13].

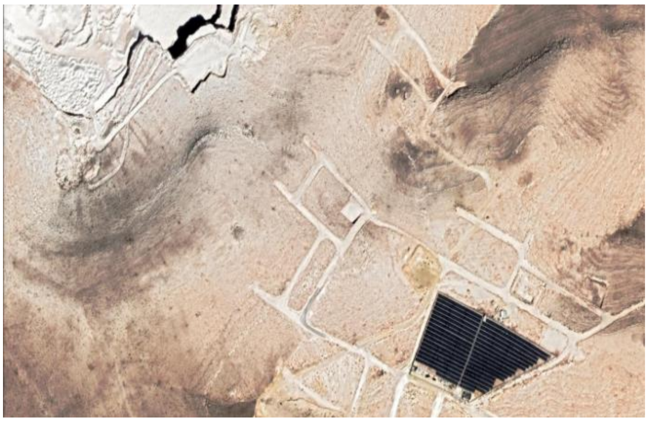

Fig.7. Aerial photo of 1.1 MW PV Plant by Google Earth®.

Fig.8. Aerial photo of 1.6 MW PV Plant by Google Earth®.

IV. Conclusion

A Matlab®/Simulink® simulation results of conditions that affects the power generation on PV solar systems is presented on this paper. A new technologies and techniques used as a solutions are suggested and discussed. PV array configurations and developments on the components and shapes of solar panels will lead an integration of several ideas to be implemented through Entrepreneurial projects.
The location of PV systems' installation is very important if these systems installed near to seaboard, these systems can be more efficient.

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