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Modelling and Simulation of PV ON Grid System Producing 10kwh in Ma'an Development AreaUsing PV_{SYST}Software.

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Abstract: *Photovoltaic or solar energy systems becomes one of the most promising field in the engineering due to environmental and energy demands issues facing the world. Most of the normal users have lacking of information about this system , this led to many of mismatching problems in the PV system string or inverters , this increase the power losses and reduces the system lifetime and its efficiency . In this study, we provide a clear way to design and simulate PV system using PVSYST software to enhance the normal user ability in designing such system and reducing the mismatching problem and power losses. in this study , a PV ON grid system is designed as case study to produce 10 KwH in Ma'an Development Area – JORDAN , the temperature and irradiance effects is studied based on data taken from The National Aeronautics and Space Administration for the selected area during one year . The inverter chosen based worst case, this improve the inverter will work probably during all time. We found a direct relationship between a irradiance and maximum power point, furthermore we find inverse relationship between temperature and maximum power point. This study open the door widely in front of normal user to design own PV system based on their needs using PVSYST software , it's also enhance their ability to overcome or reduce the mismatching problem by choosing the suitable PV module , string and inverters , knowing approximately the lifetime of PV system with its efficiency.*

Keywords: *polysilicon PV system,PV_{SYST}software,irradiance,temperature, ON grid, inverters.*

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I. Introduction

During the last decade, the using of green energy has extremely grown due to many reasons including the diminishfossil foil amount of and increasing its pollutant, economic reasons and the energy demand has grown tremendously. Solar energy has the potential over other green energy resources in Jordan domestic and urban areas due many reasons including its installation , the photovoltaic (PV) system considered easy to install and maintenance comparing to wind energy or biofuel , furthermore it totally silent , environment friendly , andinexhaustible[1].Conversely, the PV systems has few drawback in comparison with traditional energy resources including its initial cost,this includes solar panels, inverter, batteries, wiring, and for the installationcosts. However, PV systems technology are extremely growing and the initial cost going down. Moreover the PV system needs a lot of space to install, manufacturing technology associated with radiated and pollutant, and the efficiency of PV system are weather dependent variables such as sun radiations and temperature [2].finally the power losses of PV system is one of major problem facing this technology and prevent it from realizing its full market potential.Many of present problems stem from power losses due to module mismatch[3], orientation mismatch, partial shading, system design limitation and constraint, lack of monitoring and lack of analysis abilities. For example, when several modules are connected in series, each one has a lightly different maximum power point (MPP) currents resulting that the optimal MPP current to be decreased from each module[4], and the invertor will select the current which give the average power point of the string, which is normally less than the theoretical sum of the individual peak power point of every module.

In order to solve PV system power losses due so module mismatch and increasing the system efficiency [5], Anumerical closed-form solution approach is studied to examine the loss of power supply probability of stand-alone photovoltaic system [6], power control strategy by limiting the maximum feed-in power of PV systems [7], sun tracking method [8], bio-inspired methods such as Artificial bee colony (ABC) algorithm [9].

In this paper we use the PVSYSTsoftware to design a fixedPV on grid system, the main aim of this paper is to enhance normal people or the buyer's abilities to design a proper PV system based on their needs without system mismatch, i.e. selecting the best invertor and best string matching their needs, minimizing the power losses with lower cost, enhance the PV system users to use the house appliances freely without being afraid from the high electricity costs. Furthermore studying the effect of weathercondition includingthe temperature and irradiance on the selected system on selected area, which are the most important two parameters which effect the grid outputs of power.These open the door in front of knowing the efficiency of system and its realiablity and knowing the yield of any PV system.

II. Methodology.

In this work , we use PVSYST software to build a fixed PV system producing 10 KWH to meet electrical power needs on average for large house as a case study in Ma'an Development Area – JORDAN , where the PV system site to be: latitude:30.2N, longitude:35.75E, altitude:1130m and timezone:2.0 .

The PVSYST software is a tool that allows its user to accurately analyze different system configurations, evaluating the results and identify the best possible solution, grid connected system is chosen over off grid or hybrid grid due to many reasons including Jordan energy policies for domestic areas and the high cost of batteries needed for storage in off grid systems, furthermore the house location and how far it is from the utility make the on grid system is good choice for this work.

Figure (1) below shows a simplified schematic diagram of a grid connected system consist of three main parts including the PV array, system or inverters, and the final user loads. PV array in The first stage absorbs solar radiation and converts it into electricity in the form of DC currents flow throw the next stage contains an inverter necessary to convert the dc current into ac currents to fit the appliances of the house at the final stage, the excess of the power production goes to the grid.

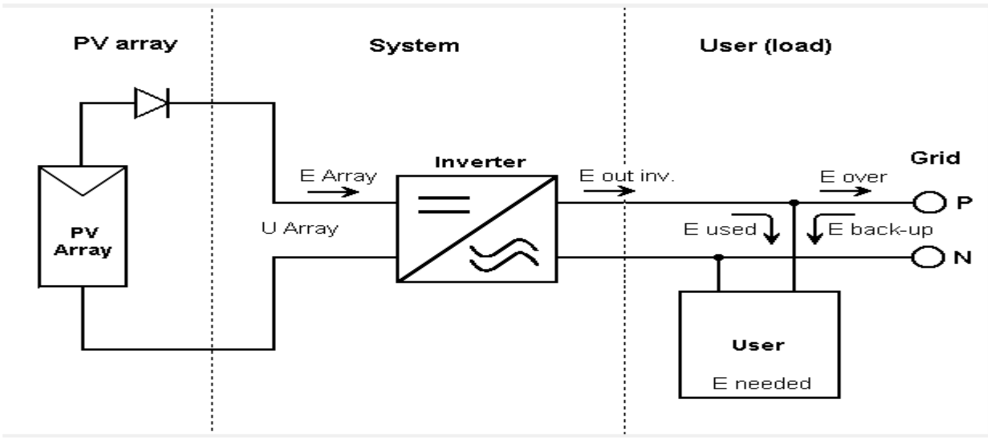

Figure 1. Fixed PV array grid connected system schematic diagram

The PVSYST software used at this step to find the best azimuth and tilt angle based on the site orientation and with the aid of the software simulation to make sure it's suitable and the most efficient for this site. Based on the panels prices and its efficiencies, 30 Si poly 30W panels was from Seraphim company to full fill our system power needs.PVSYST software build a system including string and inverters based on the power requirements and power produced by PV panel was chosen. 365 numerical data for Ma'an Development Area including temperature and irradiance was taken from NASA for one year started from 1-1-2018 until 31-12-2018 , then we observe the Max power point and losses for each day , the average of Max power point during each month and its deviation using excel sheets , the biggest deviation was calculated and was found for August. three inverters was selected from three different company based on the worst case reprehensive by the biggest deviation and based on its input and rated power ,this insure that the inverter will work smoothly and probably during the whole year.

Once the PV on grid system including the system inverter and the PV panel string is built using PVSYSTsoftware, we study the temperature effect by keepingthe irradiance constant at (STC) Standard Test Conditions at 1000 W/m² , which are the normalized operating conditions when testing the PV module, and finding maximum power point at 20C°, 35C° and 50°C, we chooses these temperatures due to weather or ambient temperature in Maan area during the year. This process is repeated by keeping this time the temperature constant at 25°C and finding maximum power point at 200,600 and 1000 W/m² respectively.

III. Results and Discussions

The best tilt angle was found using PVSYST is 30 and 0 azimuth angle to the south as shown in figure (2) below .this is very important parameters in order to orient thePV modules array in specific direction toget the maximum power on our location. It's clear that the maximum power at our location can be produced at this tilt and azimuthangle. Furthermore, the figure (3) shown below shows a horizon line drawing that and the sun path in front of the simulated PV system, which improvethe orientation for tile and azimuth angle chosen for the PV system. The PV module used in this work is fixed PV system , so during the 18 hours in the day time , the maximum power point at Ma'an Development Area happen when the slope of horizontal line drawing is zero which happen at the maximum point in the plane at tilt angle of 30 and azimuth angle of 0 .

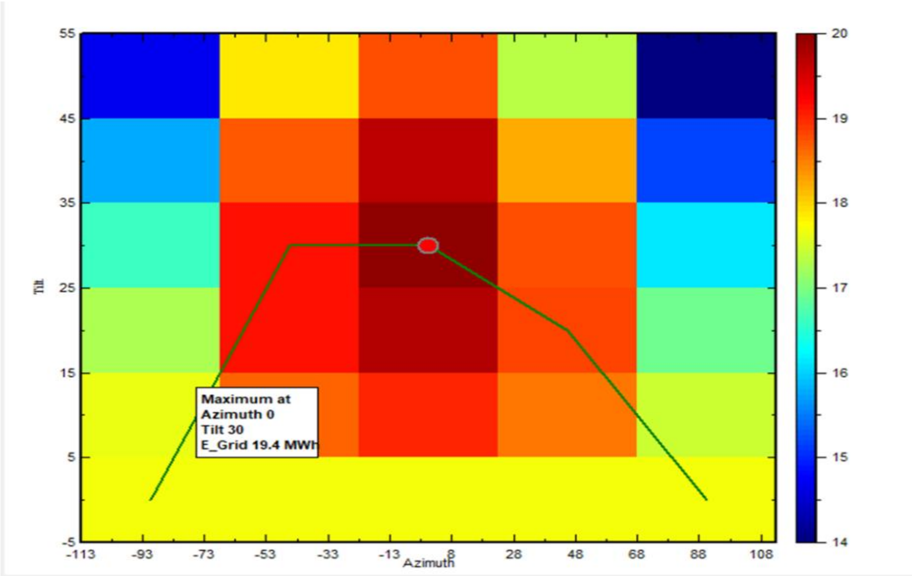

Fig 2. Maximum power at Ma'an Development Area – JORDAN Vs.tilt and azimuth angle

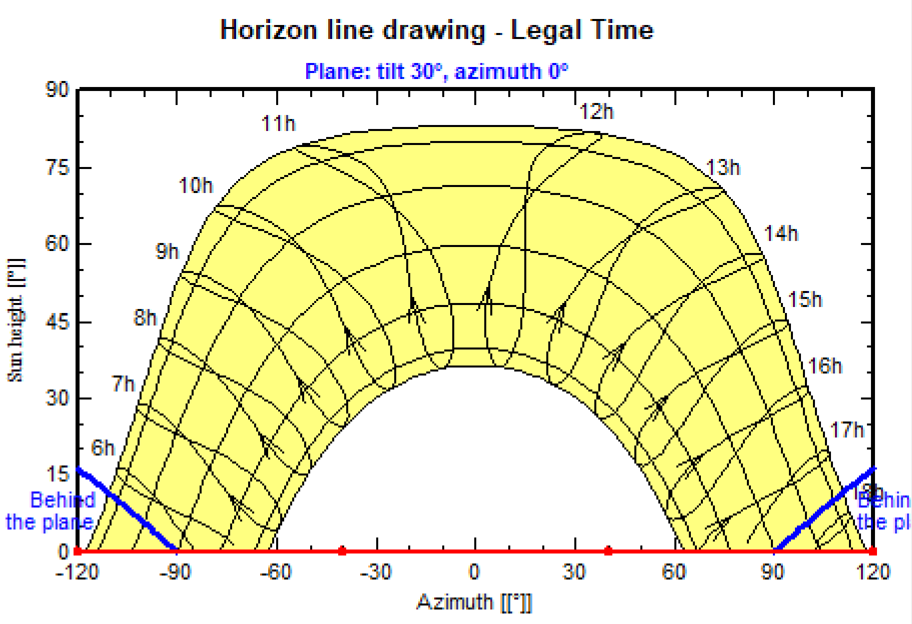

Figure 3. Horizon line drawing with the sun path inMa'an Development Area during the day time.

PVSYSTproduce three systems met the work specifications in this paper.Figures 4.a, b, and c below shows the configuration of each system, in figure 4.a, six 1.5kw string inverters from KACOCompany with 5 modules in each string. Figure 4.b, One 9 kW central inverter form SMA Company with 10 modules in each string. And in figure 4.c shows Two 8.5 kW string inverters from ABB Company with 15 modules in each.

Figure (5) shows the relationship between the PV module voltage and current at different solar irradiance levels for SMA inverter when the temperature kept at 25 °C. The figure 5 illustrates that as irradiance increases, the module generates higher current on the vertical axis and the short circuit current increases 5.4A when the irradiance 200W/m2 to 26.9 A at irradiance of 1000200W/m2, while the open circuit voltage still approximately constant around 450V .as a results the maximum power point increase as a results of increasing the irradiance due to increase the short circuit current. The current increase due to increasing the electron mobility and its kinetic energy as a results of increasing the irradiance. Where (VOC) is Open circuit output voltage, (ISC) is Short circuit output current, VMP = Maximum power output voltage, and IMP is the Maximum power output current.

figure (6) and figure (7) below shows the relationship between radiation and maximum power point in case of using KACO and ABB inverters with 1.5kw and 8.5 kw power rating respectively .it's clear that there is proportional relationship between the irradiance and the maximum power point for the three inverters due to increase the short circuit current as the irradiance increased .Figure8 summaries this relationship again and shows approximately same slop forthreeinvertors. This improve the PVSYST software options regarding the type of invertors and the module necessary to produce 10KwH in this work.

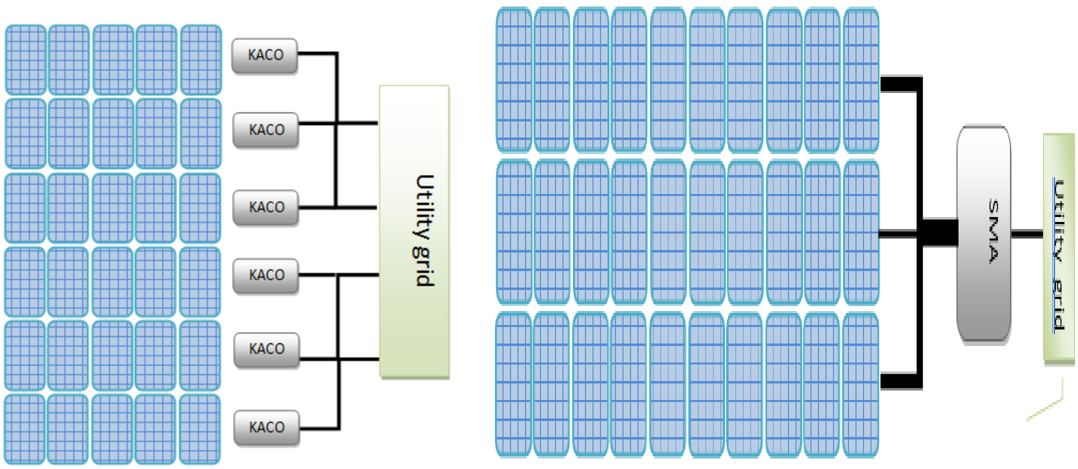

Fig4.a **Fig4**.b

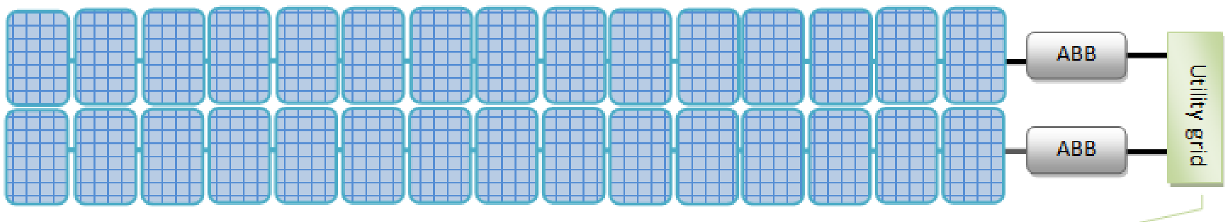

Fig4.c

Figure 4. (a). six 1.5kw string inverters from KACO Company with 5 modules in each string. (b) One 9 kW central inverter form SMA company with 10 modules in each string. (c) Two 8.5 kW string inverters from ABB company with 15 modules in each.

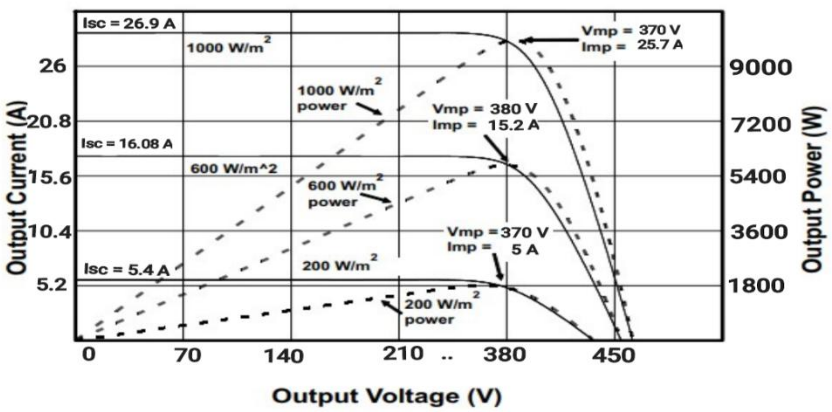

Figure (5): A PV module's current versus voltage curve varies with the irradiance or intensity of sunlight for SMA inverter.

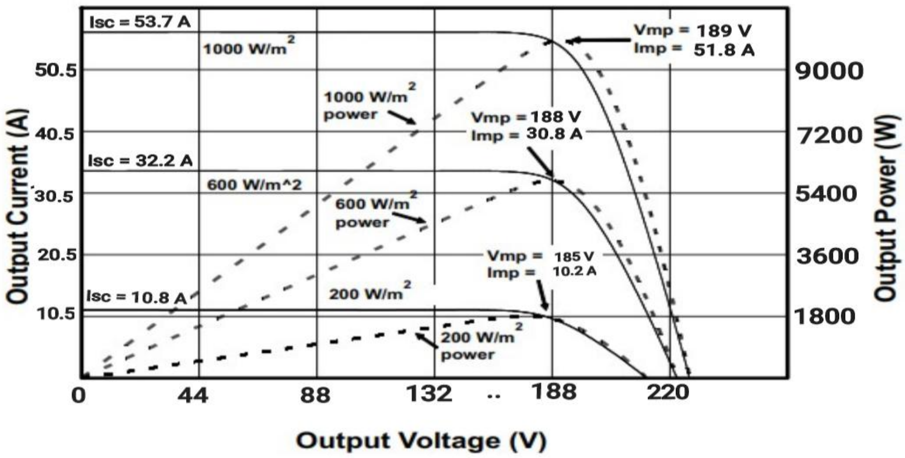

Figure (6): A PV module's current versus voltage curve varies with the irradiance or intensity of sunlight for KACO inverter.

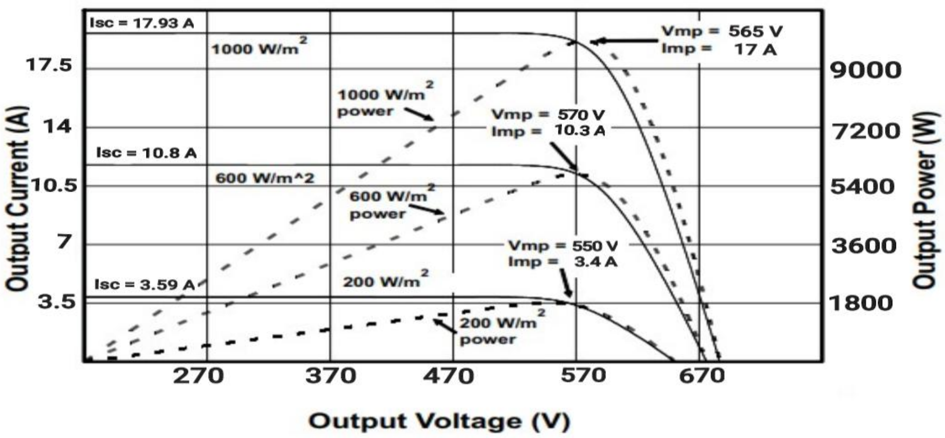

Figure (7): A PV module's current versus voltage curve varies with the irradiance or intensity of sunlight for ABB inverter.

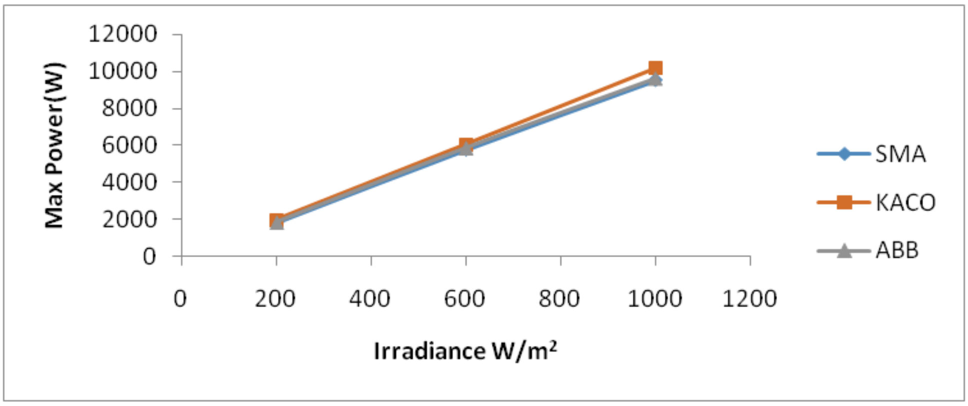

Fig.8. irradiance and max power relationship for three invertors SMA, KACO, and ABB.

In figures 9, 10 , and 11 below shows the relationship between the current and voltage for PV system once the irradiance constant at STC conditions of 1000 W/m2 and varying the temperature for three invertors SMA, KACO, and ABB respectively . the temperature is varies between 20°C and 50 °Cwith step size of 15 °C, it's clear that when all parameters are constant, the higher the temperature the lower the open circuit voltage. thermal module proprieties that are temperature dependent and thus depress the performance of a PV system ,Once the temperature increase the domains in PV module starts to re orient themselves which led to cancel some of the voltages across the module .This is considered a power lossclearing the shift in maximum power point . On the other hand, if the temperature decreases with respect to the original conditions, the PV output shows an increase in voltage and power.

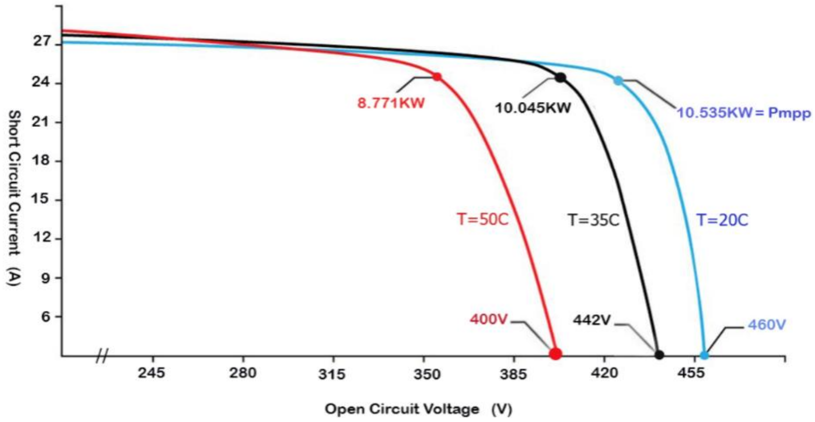

Fig.9. PV module's current versus voltage curve varies with the temperature SMA inverter.

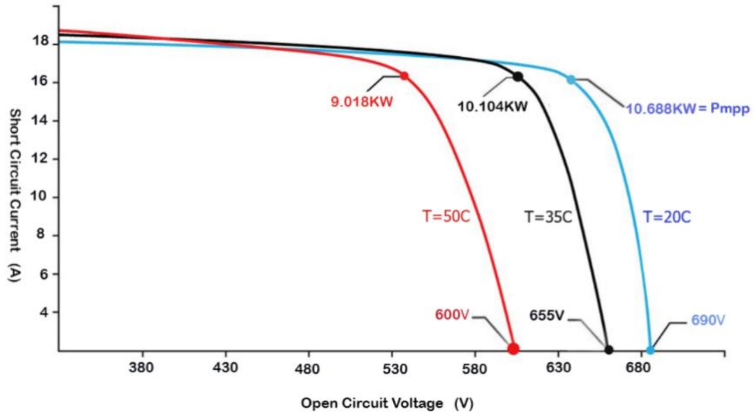

Fig.10. PV module's current versus voltage curve varies with the temperature ABB inverter.

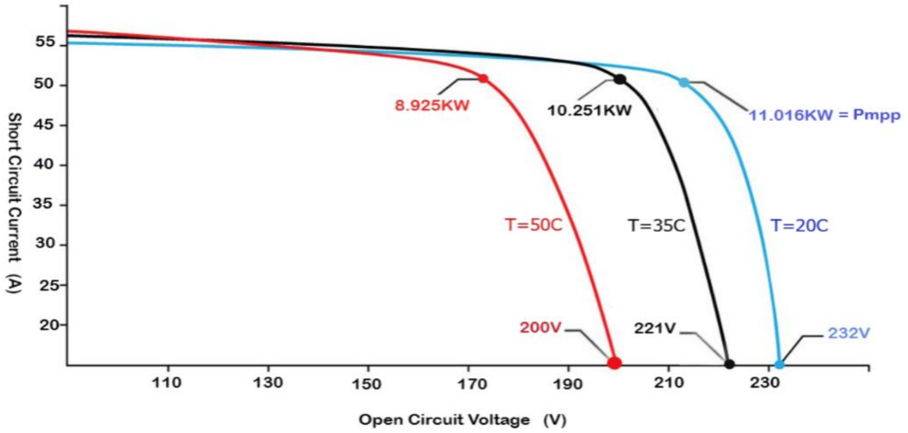

Fig.11. PV module's current versus voltage curve varies with the temperature KACO inverter.

There is approximately same inverse relationship for three mentioned invertors between the ambient temperature and the maximum power points for the needed system. This improve the PVSYSTsoftware options regarding the type of invertors and the module necessary to produce 10KwH in this work again.

The behavior of the losses affected by varying the temperature can be described as Module quality losses, Module mismatch losses, Module temperature losses, and Incidence angle modifier (IAM). Where the as Module quality losses and Module temperature lossesare directly proportional to the increase of irradiance which is logical due to the direct proportion between irradiance and heat that effect the thermal proprieties of the modules in general. While the Module mismatch losses is inversely proportional to the increase of irradiance because after a certain level of irradiance the modules production saturate and give the same levels of current and voltage which reduce the mismatch losses dramatically. Finally the IAM is inversely proportional to the increase of irradiance because after a certain level of irradiance the modules production saturate and give the same levels of current and voltage which reduce the mismatch losses dramatically.

Table 1 below show comparing between these selected inverters including its efficiency, cost and life times. all of the invertors shows approximately same efficiency in Ma'an Development Area at the same working conditions , the KACO invertors show the best life time of 10 years while the other inverters from SMA and ABB show only 5 years , conversely , the total cost is the best with SMA inverters . It's clear that the SMA inverters is the best for this study due to the logical comparison between the final cost and the life time and the amount of power produced.

Table 1. Comparison between three selected invertors SMA, KACO, and ABB.

	Inverter rated power (kw)	**Number of inverters needed**	**Efficiency of inverter (%)**	**Cost per inverter ($)**	**Total cost ($)**	**Life time (years)**
ABB	8.5	2	98.05	1743.30	3486.6	5
SMA	9	1	98.6	1 946.00	1946	5
KACO	1.5	6	95	1,479.00	8874	10

IV. Conclusions

In this work, the on grid PV system is modeled and simulated using PVSYST software in Ma'an Development Area, 365 data was taken from NASA for the irradiance and temperature for Ma'an Development Area. The system is designed and the inverters is chosen based on worst case where the maximum deviation from the maximum power point (MPP) and the average for the temperature and irradiance during the year is chosen. The best tilt and azimuth angle was found 30° and 0° respectively. the study show an proportional relationship between the maximum power point MPP and the irradiance , since the short circuit current increase rapidly with the irradiance due to the dramatically increase in the electron mobility and its kinetic energy with the irradiance . Conversely, there is reverse relationship between the temperature and theMPP, as the temperature increase the domains in polysilicon materials start to reorient themselves and some of the voltage cancelled at the modules terminals. The MPP range from 1850W to 10149 W as the irradiance varies between 200W/m2- 1000W/m2.

This study helps the normal user to design own PV system matching their requirements, with the ability of chosen the correct elements including PV string and inverters , this reducing the power mismatching losses and improving the system lifetime of PV and its efficiency .

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