Characterization of photovoltaic solar Panel efficiency for requirements of urban planning at Al-Jadyria region

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Abstract:

Sunlight has influenced building design since the beginning of architectural history. Advanced solar architecture and urban planning methods were first employed by the Greeks and Chinese, who oriented their buildings toward the south to provide light and warmth. The performance of a solar cell under sun radiation is necessary to describe the electrical parameters of the cell. A Solar panel analyzer is used for the professional testing of four solar cells at Al-Jadyria climate conditions. Voltage -current characteristics of different area solar cells operated under solar irradiation for testing their quality and determining the optimal operational parameters for maximum electrical output were obtained. The results also showed that the new solar panels have the highest efficiency (made in Spain) (efficiency=14%) compared with the older ones (made in Iraq)(efficiency less than 7%).

تقييم كفاءة الخلية الشمسية لمتطلبات التخطيط الحضري لمنطقة الجادرية

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المستخلص :

أثَرَ نورُ الشمس على بناء التصميمِ منذ بداية الت اريخ المعماريِ فللهندسة المعمارية الشمسية المتقدّمة وطرق التخطيط الحضري إستخدما أولاً مِن قِبل اليونانيين والصينيين، الذين وجّهوا ابنيتهم نحو الجنوبِ لتَزويد الضوءِ والدفءِ.

إن اداء الخلية الشمسية تحت الاشعاع الشمسي ضروري لوصف الخلية وقد استعمل جهاز محلل اداء الخلية لاختبار اربع الواح شمسية نوع سيليكون متعدد التبلور عند الظروف المناخية لمنطقة الجادرية . خصائص الفولطية - تيار لخلايا شمسية مختلفة فحصت وتحت تاثير الاشعاع الشمسي لفحص العوامل المثلى التي تعطي اعلى قدرة ، ونتائج البحث بينت ان الالواح الشمسية حديثة الصنع (اسبانية المنشأ) (الكفاءة 14%) اكثر كفاءة من نظيراتها قديمة الصنع (عراقية المنشأ) (كفاءة اقل من 7%).

Keywords: Solar cell, photovoltaic performance, building design, architecture and urban planning, efficiency

Introduction

A solar cell (also called a photovoltaic cell) is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. It is a form of photoelectric cell (in that its electrical characteristics—e.g. current, voltage, or resistance—vary when light is incident upon it) which, when exposed to light, can generate and support an electric current without being attached to any external voltage source.

The history of photovoltaic energy started in 1839 when Alexandre-Edmond Becquerel discovered the photovoltaic effect [1]. Photovoltaic system uses various materials and technologies such as crystalline silicon (c-Si), cadmium telluride (CdTe), gallium arsenide (GaAs), chalcopyrite films of copper-indium-selenide (CuInSe2), etc [1]. In solar technology, the main challenge of researchers is to improve solar cells efficiency. Due to this challenge, several investigations have been developed to characterize the solar cells by determining their parameters [2], [3] , and [4]. Indeed, it is important to know these parameters for estimating the degree of perfection and quality of silicon solar cells.

Solar cell efficiency is an important input parameter in PV-powered product design. Often, only limited space is available for the solar cells to be integrated. Cell efficiency can even become a criterion of principal system feasibility. As a basic parameter, cell efficiency serves as an input in calculating the optimal system configuration, e.g., as a cost related trade-off between the storage unit and its lifetime, PV size and its efficiency, although these calculations are well known for autonomous PV systems, e.g. [5] and

finally the demand side with correlated consumption profiles. The objectives of the present work is to study the performance of different types of solar cells

Architecture and urban planning

Sunlight has influenced building design since the beginning of architectural history. Advanced solar architecture and urban planning methods were first employed by the Greeks and Chinese, who oriented their buildings toward the south to provide light and warmth.

The common features of passive solar architecture are orientation relative to the sun, compact proportion (a low surface area to volume ratio), selective shading (overhangs) and thermal mass. When these features are tailored to the local climate and environment they can produce well-lit spaces that stay in a comfortable temperature range. Socrates' Megaron House is a classic example of passive solar design. The most recent approaches to solar design use computer modeling tying together solar lighting, heating and ventilation systems in an integrated solar design package. Active solar equipment such as pumps, fans and switchable windows can complement passive design and improve system performance.

Urban heat islands (UHI) [6] are metropolitan areas with higher temperatures than that of the surrounding environment. The higher temperatures are a result of increased absorption of the solar light by urban materials such as asphalt and concrete, which have lower albedos and higher heat capacities than those in the natural environment. A straightforward method of counteracting the UHI effect is to paint buildings and roads white and plant trees. Using these methods, a hypothetical "cool communities" program in Los Angeles has projected that urban temperatures could be reduced by approximately 3 °C at an estimated cost of US$1 billion, giving estimated total annual benefits of US$530 million from reduced air-conditioning costs and healthcare savings.

Agriculture and horticulture

Agriculture and horticulture seek to optimize the capture of solar energy in order to optimize the productivity of plants. Techniques such as timed planting cycles, tailored row orientation, staggered heights between rows and the mixing of plant varieties can improve

crop yields. While sunlight is generally considered a plentiful resource, the exceptions highlight the importance of solar energy to agriculture. During the short growing seasons of the Little Ice Age, French and English farmers employed fruit walls to maximize the collection of solar energy. These walls acted as thermal masses and accelerated ripening by keeping plants warm. Early fruit walls were built perpendicular to the ground and facing south, but over time, sloping walls were developed to make better use of sunlight. In 1699, Nicolas Fatio de Duillier even suggested using a tracking mechanism which could pivot to follow the sun [6]. Applications of solar energy in agriculture aside from growing crops include pumping water, drying crops, brooding chicks and drying chicken manure. More recently the technology has been embraced by vinters, who use the energy generated by solar panels to power grape presses.

Greenhouses convert solar light to heat, enabling year-round production and the growth (in enclosed environments) of specialty crops and other plants not naturally suited to the local climate. Primitive greenhouses were first used during Roman times to produce cucumbers year-round for the Roman emperor Tiberius. The first modern greenhouses were built in Europe in the 16th century to keep exotic plants brought back from explorations abroad [7]. Greenhouses remain an important part of horticulture today, and plastic transparent materials have also been used to similar effect in polytunnels and row covers.

Output of solar cells

The I-V curve is produced by varying R_L (load resistance) from zero to infinity and measuring the current and voltage along the way (see Fig.1). The point at which the I-V curve and resistance (R_L) intersect is the operating point of the solar cell. The current and voltage at this point are Ip and Vp, respectively. The largest operating point in the square area is the maximum output of the solar cell as it's demonstrated in Fig.2.

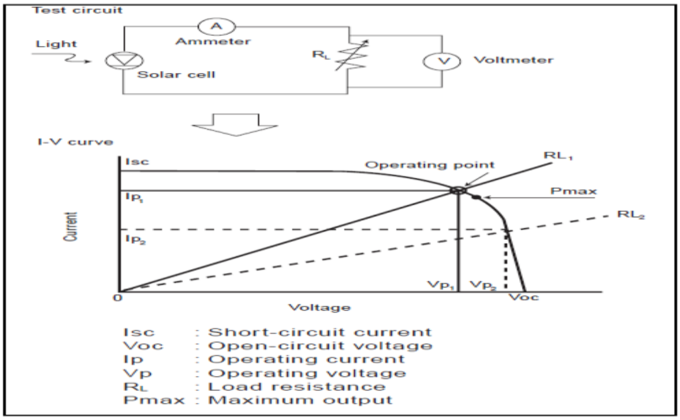

Fig.1 : The I-V curve is produced by varying R_L (load resistance) from zero to infinity.

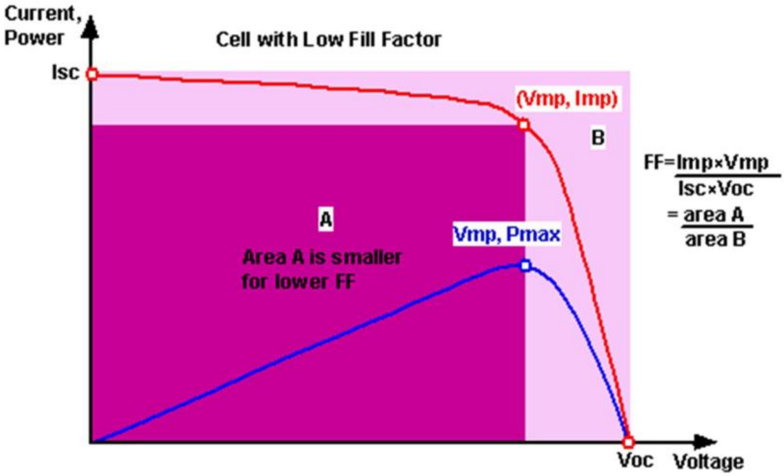

Fig.2 : Square area is the maximum power output of the solar cell.

Experimental measurements

The Prova 200 solar panel analyzer (Fig.3) is used for the professional testing and maintenance of solar panels and modules. Table 1 provides the general specification of Prova 200. In addition to maintenance and installation of solar panels, the Prova 200 solar panel analyzer can be used in the manufacturing and research of solar panels and cells. The portability of this device means that it is

also useful in quality assurance at various stages on the production line and can be taken from one location to another. When used in the installation of solar panels, the Prova 200 solar panel analyzer assists in determining the proper inverter size as well as optimum power output position of panels and helps identify defective cells or panels that have worn out over time. The solar panel analyzer also provides the user with current and voltage (I-V) test curves, maximum solar power as well as current and voltage. Solar cell efficiencies are also easily determined using the following units:

In this work, the system of measurements consisted of four silicon solar cells (types A, B, C and D) of different areas as it is presented in Fig.4. Table 2 gives the general specification of these cells, where A and D are made in Spain and B and C are made in Iraq.

Table 1: General Specifications of prova 200

Battery Type:	Rechargeable, 2500mAh (1.2V) x 8
AC Adaptor:	AC 110V or 220V input DC 12V / 1~3A output
Dimension:	257(L) x 155(W) x 57(H) mm
Weight:	1160g / 40.0oz (Batteries included)
Operation Environment:	0℃ ~ 50℃, 85% RH
Temperature Coefficient:	0.1% of full scale / ℃ (<18℃ or >28℃)
Storage Environment:	-20℃ ~ 60℃, 75% RH
Accessories:	User Manual x 1, AC adaptor x 1 Optical USB cable x 1 Rechargeable batteries x 8 Software CD x 1, Software Manual x 1 Kelvin Clips (6A max) x 1 set

Table 2: Solar cell specifications

Type	Area m^2	V_{oc} V	I_{sc} A	Peak power w	Peak Voltage V	Peak Current A	Production date
A	0.023	11	0.33	1.8	6.6	0.28	2008 (made in Spain)
B	0.228	12	2.2	18	9.0	2.0	1980 (mad in Iraq)
C	0.366	19.5	2.8	35	15.8	2.3	1986 (made in Iraq)
D	1.08	23	8.3	134	18.9	6.2	2011(made in Spain)

Fig.3 :The Prova 200 solar panel analyzer

A B C D

Fig.4: Solar cells tested type A,B,C and D

Solar panel parameters measured

The main parameters that characterize a photovoltaic panel are:

- **Short circuit current (I_{SC}): the maximum current provided by the panel when the connectors are short circuited.**
- **Open circuit voltage (V_{OC}): the maximum voltage that the panel provides when the terminals are not connected to any load (an open circuit).**
- **Maximum power point (P_{max}): the point where the power supplied by the panel is at maximum, where $P_{max} = I_{max} \times V_{max}$. The maximum power point of a panel is measured in Watts (W) or peak Watts (W_p). It is important to know that in normal conditions the panel will not work at peak conditions, as the voltage of operation is fixed by the load or the regulator. Typical values of V_{max} and I_{max} should be a bit smaller than the I_{SC} and V_{OC}.**
- **Fill factor (FF): the relation between the maximum power that the panel can actually provide and the product $I_{SC} \cdot V_{OC}$. This gives an idea of the quality of the panel because it is an indication of the type of IV characteristic curve. The closer FF is to 1, the more power a panel can provide. Common values usually are between 0.7 and 0.8.**
- **Efficiency (η): the ratio between the maximum electrical power that the panel can give to the load and the power of the solar radiation (P_L) incident on the panel. This is normally around 10-12%, depending on the type of cells (monocrystalline, polycrystalline, amorphous or thin film). The definitions of point of maximum power and the fill factor are:**

$$\eta = P_{max}/P_L = FF \cdot I_{SC} \cdot V_{OC} / P_L \qquad (1)$$

Results and discussion

The measurement results of commercial available solar cells from different manufacturers are presented. Cell samples have been investigated regarding their IV-characteristics at different solar intensities in a range of 100-1000 w/m^2 and the ambient temperature between (25-30 ºC). All the measurements and characteristics of these cells have been made within the date March 2012.

A comparison is drawn between the cell parameters and performance of the solar cell. Fig.5 shows the dependence of solar

cell maximum power with solar radiation intensity for the four solar cell types.

According to Fig.6 solar cell type A and D have the high solar output efficiency due to earlier production (2008 and 2011 respectively) as compared the other two types B and C date (1980 and 1986 respectively).

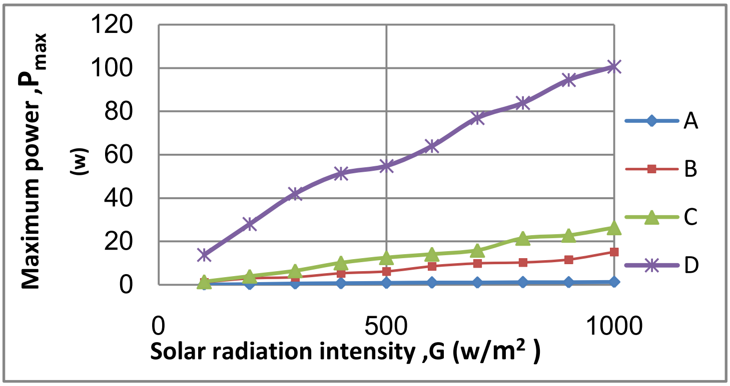

Fig. 5: Variation of solar cell maximum power with solar radiation intensity for the four solar cell types.

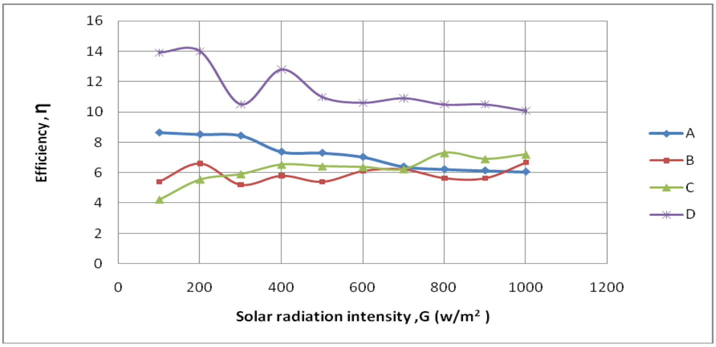

Fig. 6: Variation of solar cell efficiency with solar radiation intensity for the four solar cell types.

Conclusions

The performance of a solar cell under sun radiation is necessary to describe the electrical parameters of the cell. Effect of production date on the performance of a photovoltaic solar system was investigated. The results show that there is a flyctuation in solar cell The efficiency with the values of irradiance. Solar cell type A and D have the high solar output efficiency due to earlier production date (2008 and 2011 respectively) as compared the other two types B and C (1980 and 1986 respectively).

Nomenclature

FF Fill factor
G Solar radiation, w/m^2
P Production date
P_{max} Maximum Solar Power, w
P_L Power of Solar radiation, w
R_L Load resistance, Ω
V_{maxp} , V_{mp} Maximum Voltage at P_{max}, V
V_{oc} Voltage at open circuit, V
I_L Photocurrent, A
I_P Operating current, A
I_o Saturation current, A
I_{maxp} , I_{mp} Maximum Current at P_{max} , mA
I_{sc} Current at short circuit, mA
η Efficiency, %

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